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COGNITION AND ACHIEVEMENT: AN EXAMINATION OF INDIVIDUAL DIFFERENCES AMONG GRADE TEN STUDENTS

by

ROLAND AIME LAMBERT

A THESIS
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ABSTRACT

THESIS: Cognition and Achievement: an Examination of Individual Differences among Grade Ten Students.

The problem of interpreting inter-individual differences in academic achievement was thought to be solved with the development of the intelligence test. However, it soon became apparent that intelligence tests predicted achievement with only limited success. And, in spite of the attempts that have been made in recent years to identify factors other than measured intelligence that contribute to achievement, the problem clearly requires additional research. In this experiment an attempt has been made to identify factors that have been little considered by earlier researchers.

Two major hypotheses were tested:

1. Subjects classified as overachievers, average achievers and underachievers will show differences in the efficiency with which concept formation tasks are solved.

2. Subjects classified as overachievers, average achievers and underachievers will show differences in scores on creativity measures.

Three groups of subjects (a group of overachievers ,

a group of average achievers, and a group of underachievers) were selected for the study from among Grade Ten students in attendance at West Jasper Place High School, Jasper Place, Alberta, during the 1961-62 school year. Tests of creativity were administered to the subjects; they were also set a number of concept formation tasks.

A special measure of problem-solving efficiency was developed for the purpose of analyzing performance on the concept formation tasks. When this measure was employed, overachievers were demonstrated to be more efficient than average achievers, who were, in turn, more efficient than underachievers. Similarly, when performance on the creativity tests was analyzed, overachievers were shown to be more creative than average achievers, and average achievers more creative than underachievers. Of the four indices of creativity distinguished by the tests--Fluency, Flexibility, Originality, and Elaboration--Flexibility discriminated most effectively among groups.

On the basis of these findings, and subject to the limitations imposed through the use of a small sample, it can be concluded that academic achievement is a function of certain aspects of behaviour measured by concept formation tasks and creativity tests but inadequately sampled by intelligence tests.

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CHAPTER I

INTRODUCTION TO THE PROBLEM

Education is a sequence of educative acts designed to promote behaviour changes in students. Implicit in any educative act are three processes: (1) the formulation of a desired behaviour change; (2) the organization of learning experiences designed to elicit the desired behaviour change; (3) the evaluation of the learning to determine whether the desired behaviour change has taken place. Although attention is focused on the evaluative process in this study,no suggestion that evaluation is more important than the formulation of objectives or the organization of learning experiences is intended. Nor is there any intention to minimize the importance of the relationships among these three processes. Improving evaluative procedures is one way of improving the educative act and, in turn, education in general.

Clearly evaluation is a judgment based on the comparison of samples of a student's behaviour with some standard of performance. In actual practice, samples of behaviour are obtained from observations of a student's behaviour in the classroom and on the playground, from responses to teacher-made tests, and from responses to

standardized achievement tests. Standards of performance vary from a highly subjective standard based on the teacher's past experience with similar situations to a highly objective standard made available by standardized tests.

The process of evaluation, if it is to be systematic, must be consistent with the basic principles of measurement. Evaluation, therefore, must be based on the comparison of the best available representative sample of a student's behaviour with a highly objective and valid standard of performance.

English and English (1958) define evaluation as "the measurement of the attainment of educational goals, however defined." McDonald (1959) defines standardized achievement tests as "those that may be used to measure the attainment of objectives of learning experiences." From these two strikingly similar definitions one can assume that valid and reliable standardized tests are the present day educator's best source of the raw materials required to make evaluative judgments, consistent with the principles of measurement. Adequately standardized tests are limited in number. Where no appropriate test exists the educator, although cognisant of the mistakes made by his forerunners, continues to make evaluative judgments on less adequate samples of behaviour and more subjective standards of performance.

In spite of the apparent sophistication of the evaluative process, variations in achievement have yet to be satisfactorily explained. At the outset of this century the methods used in the attempts to explain differences in achievement were based on three assumptions: (1) standardized achievement tests accurately measure achievement; (2) intelligence tests accurately measure capacity (potential achievement), and (3) that a direct relationship exists between intelligence and achievement scores.

Intelligence did, in fact, account for some of the differences in achievement but differences between individuals of apparently equal ability remained. Assuming that two individuals of like ability also had similar educational opportunities then individual differences in, for example, effort, had to account for differences in achievement. Teachers were expected to measure 'effort' by comparing the student's achievement and intelligence scores. These ideas were sufficiently crystallized by 1920 to appear in print in two independent studies, one by Munroe and Buckingham, the other by Franzen.

Munroe and Buckingham (1920) produced the Illinois Examination, a standardized group test battery which included general intelligence, arithmetic, and silent

reading tests. The norms for reading and arithmetic were derived from the performance of pupils of the same mental age as indicated by the intelligence test. The achievement norms were expressed in achievement ages; intelligence was expressed in mental ages; and efficiency, calculated by dividing an individual's mental age into his achievement age, was expressed as an achievement quotient (A.Q.). Franzen (1920) developed another A.Q. which he christened the Accomplishment Quotient. The ratio of educational age to chronological age was the educational quotient (E.Q.). The ratio of the educational quotient (E.Q.) to intelligence quotient (I.Q.) was the accomplishment quotient (A.Q.). Franzen (1920) argued:

> Since the I.Q. is the potential rate of progress, the ratio E.Q.:I.Q. gives the percentage of what that child could do to what he has actually done . . . . It is, therefore, safe to assume that the optimum A.Q. is 100.

The A.Q. (by whatever definition) was enthusiastically received in educational circles.

> The A.Q. is the most exact present-day measure of the efficiency of study, instruction, and supervision. It is the best index of what pupils need special attention and spurring, of what pupils need restraining perhaps, and of what pupils need to be left alone . . . . It is a device for converting pupils, no matter what their intelligence, into standard pupils. (McCall, 1922)

McCall's (1922) statement that A.Q. "is a device for converting pupils . . . into standard pupils" failed to explain how this 'conversion' was to be made, "Fifty

years ago deficiencies in learning could be attributed to a bad will or a weak mind" (McDonald, 1959). Failure to use what intelligence one had and 'lack of intelligence' suggested that achievement quotients could not exceed 100 but A.Q.'s did, on occasion, exceed this limit. Ratio scores greater than 100 seemed much more difficult to explain than those below 100 and, in the opinion of the writer, neither has been satisfactorily explained.

THE PROBLEM

Educators have long been anxious to elucidate the nature of differences in academic achievement. In the years immediately following the development of intelligence tests, attempts were made to interpret these differences in terms of measured intelligence. However, it became evident soon after intelligence tests came into common use that such a technique of explanation raised a series of new and awkward questions. Although significant relationships were found to exist between measured intelligence and achievement, there were sufficiently large discrepancies to suggest that factors other than measured intelligence influenced achievement. The problem which achievement poses for modern educators thus becomes the search for variables other than measured intelligence that are strongly related to achievement. The review of the

literature, as contained in Chapter II, lists and examines the more important aspects of this search.

CHAPTER II

REVIEW OF THE LITERATURE

Early Attempts to Explain Differences in Achievement.

As mentioned in the introduction, the initial systematic attempt to explain differences in achievement resulted in the formulation of an achievement to intelligence ratio score (A.Q.). However, investigators soon found differences in achievement that could not be explained by differences in intelligence. Bright elementary school pupils as a group were not achieving up to expectations (Pintner, 1922), high school and college students of above average ability were achieving at an average or below average standard (Peters, 1926), and pupils of below average intelligence were doing better than expected (Franzen, 1922).

Various explanations of these differences were attempted. Those who accepted the A.Q. as a valid measure of learning efficiency attributed the differences to the school system or the teachers.

> The mental legacy which they (those of low mental ability) inherit is slender, yet so judiciously have their teachers invested and improved it that the accumulated interest now exceeds the capital. (Burt, 1921)

Burt's observation might have satisfactorily explained

the 'better than expected' results obtained by the dull children but did not account for the bright students' 'lower than expected' scores. Pintner,(1922) attempted to explain both discrepancies in a similar way.

> The tendency of the school is to push ahead the mentally slow and at the same time to neglect the bright as soon as they have achieved average work. (Pinter, 1922)

It was difficult to understand how teachers could be "so judicious" and at the same time "neglect the bright."

Other writers turned to some aspect of the school system as an explanation of an A.Q. lower or greater than 100, for example, grading procedures.

> It has been produced through the artificial system of the traditional school with its improper grading and classification. (Torgenson and Shuman, 1925)

Similarily, the amount of time spent at school was assumed to account for some of the differences.

> Grade placement has an effect on a pupil's performance. (Torgenson, 1922) Learning is a function of the time one has been learning as well as ability. (Goodenough, 1925)

Franzen (1922) criticized the achievement scores used to calculate A.Q. His assertion that "achievement norms are too low," had it been correct, would have effectively eliminated A.Q.'s over 100 and greatly increased the number of A.Q.'s below 100 which Franzen did not explain.

The work of these early psychologists emphasized the need for: (1) satisfactory explanations of the discrepancies

between actual and predicted scores, and (2) an adequate vocabulary to describe these discrepancies.

Changes in Terminology

Subjects could be classified on an intelligence dimension as dull, normal, or superior; or on an achievement dimension as low achievers, average achievers, or high achievers. Terms were required to classify subjects on an A.Q. dimension. Retarded (Schonell, 1936) and backward (Alexander, 1940) referred to A.Q.'s below 100.

The terms underachievement and overachievement dichotomized the A.Q. deviations. At the present time, these terms best describe the discrepancies between achievement scores and intelligence scores. Terms that divide the A.Q. dimension into three or more groups are still required.

Assuming that discrepancies between intelligence and achievement are normally distributed some clarity might be attained through defining as 'standard achievers', for example, those individuals whose deviations are within one standard deviation from the mean. Subjects whose scores are beyond one standard deviation from the mean would then become underachievers or overachievers according to the direction of the deviation. In practice, investigators

arbitrarily set the limits within which scores must fall to indicate underachievement or overachievement. The limits set for sample selection vary from study to study increasing the difficulty of interpreting and comparing results.

In recent studies underachievers and overachievers have been selected respectively from the lower and upper extremes of the normal distribution of discrepancies between achievement scores and intelligence scores. By whatever definition, underachievement and overachievement are the terms most commonly used to describe subjects whose achievement scores are not commensurate with their intelligence scores.

Research on Underachievement and Overachievement

Many underachievement and overachievement studies have attempted, with varying degrees of success, to explain why students whose scores on intelligence tests suggest similar ability do not, in fact, perform equally well on achievement tests. The literature in this area of study is so extensive that only the results of some recent studies are included in the review. For purposes of discussion correlates of underachievement and overachievement are here classified as: environmental, personal, emotional, motivational, and personality factors, although some intermingling of these factors is inevitable.

A. Environmental Factors

The Effect of Home and Family Background. Frazer (1959) finds that home environment correlates .687 with intelligence and .752 with achievement. The difference between these correlations she reports as highly significant.

> Of the ten items which make up this composite assessment of home environment, three stand out as being mainly responsible for the higher correlation with school progress. These are in order: abnormal background, income, and parents' attitudes to the education and future occupation of the child. (Frazer, 1959)

Frazer's findings regarding parental attitude toward education corroborate Ford's (1957) findings that the parents of underachievers and overachievers differ in: (1) their attitudes toward school,and (2) the amount of punishment and scolding they mete out for poor marks. Ford, however, finds achievement unrelated to social class, occupation of the father, education of the mother, or family size.

Edelston (1950) attributes considerable importance to poor home condition as a cause of underachievement, pointing out as unsatisfactory: (1) homes in which the parents are indifferent towards the child and, (2) homes in which parents are too insistent that the child make high marks.

McQuary (1954) reports that underachievers are more

likely to have had less fortunate backgrounds: fewer of their fathers are engaged in professional or semi-professional occupations, both parents have less formal education, and finances are more limited.

Siegel (1954) attributes the significance of 'unfortunate home condition' to: "family relationships which condition the child's ability to follow directions, his use of language, and his background of understanding."

Frankel (1960) compares the home and family backgrounds of underachievers and overachievers. The physical aspects are very much alike. However, differences in socio-economic status, and in education and occupation of the parents, are significantly in favor of the overachievers.

Tibbett (1954) concludes that broken homes have an adverse effect on achievement while Anspaugh (1953) concludes that there is no direct evidence that broken homes and school grades are related.

The Influence of Society.

(a) Values. Sociologists point out that our school system is dominated by middle-class values. Lindgren (1956) reports that the lower-class child cannot accept middle-class values, cannot identify with his middle-class teacher and is "likely to fail academically regardless of intellectual abilities."

Winter (1961), investigating the effect of similarity between a student's values and those of his teacher using a modified form of the semantic differential, finds that the greater the similarity between a student's values and those of his teacher the higher his achievement score. The student's ability to predict his teacher's values also correlates with his achievement score.

(b) Mass Media of Communication. Wallace (1960) studies the effect of mass media of communication on the achievement of Negro elementary school children. She reports that time spent watching television, time spent listening to the radio, the number of comic books read, the number of movies attended, and the frequency of Sunday School attendance are inversely related to school achievement. Research of this type underscores the fact that the school must compete with other media of communication for the students' attention. The implication is that some of the techniques used in mass media might with profit be employed by the school.

Peer Group Influence. West and Sievers (1960) consider the effect of changes in school environment. They argue that ability grouping seems necessary because some learn more quickly than others. However, isolating ability groups for the entire school day presents a number of prob-

lems such as undesirable attitudes and relationships between pupils and teachers and the denial of leadership and stimulation which high ability pupils provide for their classmates. Cross-grouping was attempted as a compromise. West and Sievers report no significant loss in social relationships; significant gains in academic achievement; and increased opportunity to develop creative talents and to encourage aesthetic appreciation.

French (1960) studies the effectiveness of ability grouping from school records. No relationship is found between achievement and homogeneity of ability within classes. The findings of these two studies suggest that the disadvantages of ability grouping cancel out the advantages.

Porterfield and Schlichting (1961) find a significant relationship between 'peer prestige status' and reading achievement. There are some differences depending on socio-economic level; for example, in the lower socio-economic group achievement is not related to either social acceptability or leadership in sports. It is not intended to suggest that peer grouping has no effect on children of low socio-economic status but rather that these children seek status outside the school situation. Lindgren, as reported earlier, explained this observation in terms of the

discrepancy between lower class values and the school's middle class value.

Further doubt is cast on ability grouping by Powell and Parsley (1961) who report a correlation of .19 between first grade reading readiness and second grade reading achievement. It would appear from this study that grouping beginning second graders solely on the basis of first grade achievement cannot be justified.

Granzow (1954) finds that underachievers are not as readily accepted by their peers as either the 'normal' achievers or the overachievers.

Robinowitz (1956) suggests that overachievers, doubtful pf their acceptability to the peer group, put forth extra effort in the academic situation.

Summary. The research on environmental factors is of doubtful value because: (1) too many contradictions are found; (2) correlations vary widely; (3) correlates have a low predictive value; (4) measures of home environment tend to rest on the subjective judgments of home visitors; and (5) there is a lack of detailed theory to explain the association between achievement and environmental variables.

B. Personal Factors

Vocational Interests and Aspirations. Carter and McGinnis (1953) report that overachievers enter college with a definite vocational choice while underachievers have no definite vocational plan.

Malloy (1954) finds that overachievers have a higher level of aspiration, are more attracted to challenging goals and are more persistent than underachievers.

Morgan (1952) and Coleman (1960) examine the scores of overachievers on the Occupational Level scale of the Strong Vocational Interest Blank. In both studies the interests of overachievers are reported as similar to the interests of managerial and professional persons.

Frankel (1960) reports that overachievers see college as preparatory to graduate school while underachievers see college as vocational preparation.

In general, both interests and level of aspiration are higher for overachievers than for underachievers.

Study Habits. Chapman (1958), Gough (1953), Gowan (1955), Stasek (1955), Popham (1960), and Davidson (1950) report that overachievers have better study habits than do underachievers. Overachievers respond promptly to study demands (Brown, 1954), meet deadlines (Malloy, 1955), and work alone (Owens, 1949). Underachievers spend less time

in study, miss more classes, have an irregular study schedule, fail to meet deadlines, take poorer notes in class, and are more likely to be lured away from studying. (Rust, 1958)

Overachievers are more likely to be female (Ford, 1957); to have library skill (Joyce, 1961); to do more reading, to have good study habits and to have a definite vocational plan. Underachievers are more likely to be male; to lack library skill; to do less reading; to have poor study habits and to lack a definite vocational plan.

C. Emotional Factors

A positive relationship between emotional instability and underachievement is noted by several writers (Stagner, 1932),(Hadley and Kennedy, 1949),(Edelston, 1950), and (Boyce, 1956).

Hoyt and Norman (1954) compare the achievement scores of three groups: highly maladjusted, partially maladjusted, and normal. The findings suggests emotional disturbance may cause some to overcompensate and consequently to overachieve and others to dwell on the problem to the exclusion of study and consequently to underachieve.

Kunce (1960) compares the records of a group requiring psychiatric care and a normal group matched for sex and

intelligence. He concludes that the degree to which subjects fail to achieve as well as their intelligence scores predict is related to the degree of emotional disturbance.

In a similar experiment Griffiths (1945) finds no differences between groups rated as poorly adjusted and well adjusted on the basis of the Bell Adjustment Inventory. In fact, "men with very unsatisfactory adjustment scores tend toward higher grades than men with excellent adjustment scores." (Griffith, 1945)

Fendrick and Bond (1940) find a strong relationship between reading disability and juvenile delinquency. Gates and Bond (1937) observe a wide variety of symptomatic reactions attributable to reading disability from which they infer that learning disability causes emotional and personal maladjustment. Brueckner and Bond (1955) point out that there are studies (Hoyt and Norman, 1954) which show that some children with severe emotional problems compensate for their difficulties by excessive educational striving, thus becoming extremely competent students. On the basis of research findings such as these one would expect to find rather severe educational disabilities in most children with emotional disturbances requiring residential psychiatric treatment.

Tamkin (1960) studies educational disability in emotionally disturbed children. He finds that only one

third of the emotionally handicapped children have accompanying educational disabilities.

> The findings are most compatible with the theory that educational disability is merely a sympton which might be produced by the same condition responsible for the emotional disorder. Certainly, emotional problems could not be construed as a cause of educational disability since, as the results demonstrate only one third of the emotionally disturbed sample had accompanying educational disabilities. (Tamkin, 1960)

The only conclusion that can legitimately be drawn from the results of these studies is that emotional disturbance affects individuals in different ways.

D. The Motivation Factor

Individuals work more effectively when a keen desire to do so is present; consequently, much research has been devoted to understanding the relationship between achievement and motivation.

Correlations near zero are reported between undergraduate and graduate achievement scores (Schwartz and Clark, 1959). Two explanations are given for the low correlations: (1) diversity of standards among different institutions, and (2) a number of bright students lack motivation at the undergraduate level.

Chabassol (1959) concludes that "the underachiever may reveal an inability to put forth a persistent and sustained effort for any length of time" which he attributes

to "a desire for immediate gratification and a disinclination or an ability to seek out long range goals."

Wrightsman (1960) reports that lack of motivation is related to underachievement.

Carter (1961) finds that achievement in a college course in educational psychology is related to the degree of scholarly motivation possessed by a student.

Feder and Kounin (1940) observe that the highly motivated student shows greater correspondence between ability and achievement.

Anderson (1954) explains that: "the theory of deficient motivation" remains an inadequate basis for understanding underachievement until: "the true nature of motivation is more widely understood." (Anderson, 1954)

Several investigators Krug, 1959; Burgess, 1956; Ward, 1960; Fair, 1959; Malloy, 1955 find motivation, as measured in terms of muscular tension, for example, significantly related to academic achievement.

The Inevitable conclusion from the foregoing studies is that motivation, once it is better understood, will help to explain discrepancies between intelligence and achievement scores. However, a doubt is cast by Marsh (1959) and Reed (1959) both of whom report that no evidence of a relationship between motivation and achievement could be detected in their studies.

E. Personality Factors

Personality continues to be a fruitful source of hypotheses to explain individual differences in achievement. Many investigators expect to find and do find that achievement correlates with one or more personality traits.

Henkelman (1952) finds that objectivity, composure, and self-mastery are strongly related to achievement.

Field (1954) reports that overachievers differ from underachievers on three scales of the Minnesota Multiphasic Personality Inventory: Conformity, Inquiring Intellect, and Confident Self-Expression.

MacCurdy (1956), with a group of superior science students as the sample, attempts to find what personality traits the subjects have in common. He reports that they exhibit leadership qualities: Self-control, self-discipline, curiosity, rationality, persistence, and a lack of gregariousness.

Fair (1959), in a study attempting to relate underachievement to personality variables, finds that none of the eighteen scales on the California Personality Inventory distinguished 'probationers' (students whom teachers have reported as not working up to capacity) from 'non-probationers'.

Bendig (1960) studies the relationship of extra-

version and neuroticism to achievement. In a sample of 202 male psychology students he finds achievement correlates positively with extraversion, but does not correlate with neuroticism.

In a similar study by Lynn (1955) different findings are reported. Lynn finds that good students differ from poor students: the former score significantly higher on the neuroticism dimension and the latter score higher on the extraversion scale.

Differences in results such as those reported by Lynn and Bendig would seem to be the result of differences in sampling. However, further study is required to clarify the relationship investigated.

Of all the personality variables found to be related to achievement the one that has received most attention in recent studies is conformity.

Coleman (1960) finds that overachievers are rated as lower than underachievers on the Change Scale of the Edwards Personal Preference Schedule. She interprets this difference to mean that overachievers feel less need to change activities frequently. Assuming that the Change Scale measures an individual's need to seek out the new and different, while conformity implies a tendency to adhere to established procedures Coleman's interpretation

corresponds with Field's (1954) finding that overachievers score markedly higher on the conformity scale of the Minnesota Multiphasic Personality Inventory; with Brown's (1954) finding that underachievers are unwilling to conform; and with Frankel's (1960) finding that overachievers are more conforming than underachievers.

The overachievers' low need for conformity would seem to indicate a lack of flexibility. Similarly the underachievers' high need for conformity would seem to indicate a higher degree of flexibility. However, low achieving students express a higher interest in the familiar and stable situations while high achievers prefer more abstract situations. (Ward, 1960) To the degree that low achievers are also underachievers and high achievers are also overachievers the implication from Ward's finding is that overachievers are more flexible than underachievers.

Study of the relationship between achievement and personality variables presents a number of problems:

1. Definitions of personality traits are not mutually exclusive, making interpretation of results difficult.

2. The different interpretations of results are not always compatible.

3. Personality variables because of their relative stability cannot be used to effect changes in achievement.

4. Studies attempting to identify groups of overachievers on the basis of personality traits have proved rather unsatisfactory.

5. The usefulness of personality traits in predicting level of achievement is questionable.

F. General Summary

The literature on achievement correlates reveals a vast number of attempts to explain individual differences in achievement. The results are somewhat inconsistent.

Lack of consistency in the use of terms such as low achiever, high achiever, underachiever and overachiever accounts for some of the difficulty. Variations in sampling and the lack of validity in the instruments used to assess the variables may account for the wide variation in the size of correlation coefficients reported by investigators presumably studying the effect of the same variable.

Several studies (Mazaroff, 1936; Black, 1949; Nelson, 1949; Stone, 1954; Levine, 1958; Zurowsky, 1959; Fleming, 1959) conclude that achievement scores, although poor predictors, are the best available predictors of future scholastic achievement. The low predictive value of achievement correlates indicates that there is some difficulty in isolating suitable variables.

The chief source of difficulty is a lack of detailed

theory to explain the association between achievement scores and scores on other variables chosen for study. Since both achievement and intelligence are cognitive functions, discrepancies between them should be predictable in terms of cognitive theory.

Cognition and Achievement

Definition of Cognition. Cognition is a generic term which includes the supplementary processes of perceiving and thinking. Either may predominate in any given cognitive process; for example, problem solving primarily involves thinking. Cognition is the more general term but thinking is often defined as a synonym.

> Thinking is a general term referring to the occurrence of central events which are not simply initiated by the specific stimulus situation in which the individual finds himself and which are in part directly experienced as thoughts, ideas, images, and so on. (Gagne, 1959)

The occurrence of central events means that the stimulus does not determine the response; rather the response is dependent on some combination of the initiating stimulus and previously encountered stimuli now stored in memory. While the definition is acceptable to most psychologists, the explanation and measurement of cognitive functioning varies with the school of thought of the psychologist. The computer model, the neo-behaviouristic and the non-behaviouristic approaches are all worthy of mention

since each makes a contribution to this study.

Non-Behaviouristic Approach. Non-behaviourists as a group do not form a school of psychology. Classified as non-behaviourists are those psychologists whose work is not bound by the standards imposed by the neo-behaviourists.

Bruner is considered a non-behaviourist because his work is largely composed of 'good guesses' expressed in unorthodox terms, supported by meagre experimental evidence, and lacking theoretical foundation. However, some of his ideas have a direct bearing on this study. For example, he suggests what seems to be a logical approach to better understanding of the problem solving process.

Bruner (1956) describes the environment as a "tremendous array of discriminately different objects" which we have the ability to classify. He calls the process of grouping objects into classes and responding in terms of class membership rather than in terms of the uniqueness of each object 'categorizing'. Categorizing, in behaviouristic terms, is coding at the integration level and is subject to previous coding systems. (Osgood, 1960) There is little doubt that categorizing (coding) is a continuous process, but it is difficult for an investigator to follow the steps involved unless the individual is thinking about a formal problem known to the observer.

Bruner has studied the thinking process involved in solving formal problems. A formal problem is defined "by a stimulus situation and instructions which establish sets and define the goal." (Bruner, 1956) The investigator controls the problem situation so that the subject's thinking may be observed while information which constitutes the stimulus situation is successively added.

Bruner designed a number of tasks to externalize the thinking process, the simplest of which requires the subject to discriminate between two variables, in effect to select one of two possible alternatives. For example, a subject might be shown a picture of a sea anemone and asked whether it was a plant or an animal. The first response is either correct or incorrect; moreover, whatever the subject's first choice, when confirmation or denial occurs there is sufficient information available to solve the task correctly. Bruner devised more complex tasks requiring the individual to make a series of choices, each of which might or might not bring him relatively nearer the desired solution.

The complexity of the task may be increased, for example by increasing the number of variables to four. In this case the individual could solve the task on his first choice only if he chose the correct response. If he chose one of the faulty leads, at least one and perhaps two more choices would be required.

The addition of attributes may also increase the complexity of the task, thus insuring a sequence of choices. Attributes are discriminably different aspects of a variable. For example, if the variable is color, then red, blue, and yellow are attributes: Similarly, if the variable is blue, then light blue and dark blue are attributes.

The usual concept formation task is made up of as many as eight variables, each of which has two attributes. Using eight variables with two attributes each, sixteen discriminably different representations, which Bruner calls instances, are possible. Assuming the eight variables to be colors and the attributes lightness or darkness, several concepts are possible; for example, all the red instances, or all the dark red instances, or all the light yellow instances. The examiner selects a class (concept) which the subject attempts to identify on the basis of a series of confirmed or denied instances.

Bruner analyzed performances on concept formation tasks. He found that the individual's choices revealed his system of problem solving, that is, the pattern of choices revealed the strategy.

Bruner classified the patterns of selections into what he called four ideal strategies, which he labelled and defined as follows:

1. Simultaneous Scanning means that the subject uses each instance in turn to deduce which hypotheses are still tenable and which have been eliminated. The individual plans each step so that his next choice will be maximally informative. After each choice he must remember which concepts have been eliminated or which concepts are still tenable and carry this information through to the end of the problem.

2. Successive Scanning consists of testing a single hypothesis at a time. After choosing an hypothesis the subject limits his choices to those instances that are a direct test of this hypothesis. The strategy does not guarantee maximum information from each choice. Nor can the individual regulate risk, since a particular choice may provide much, some, or no information.

3. Conservative Focussing consists of finding a positive instance of the concept sought, then making a sequence of choices which alter one attribute at a time, thus discovering whether or not a change yields a positive or a negative instance. Positive instances are highly informative.

4. Focus Gambling also uses a positive instance as a focus; however, the individual changes more than one attribute value at a time. Negative choices may provide more or less information than do positive choices; positive

choices maximize information.

According to Bruner, variations in the following five conditions account for differences in the strategy used:

1. The definition of the task.
2. The nature of the instances encountered.
3. The nature of validation.
4. The consequences of specific categorizations.
5. The nature of imposed restrictions.

Others attempt to account for the differences in strategies. Kendler and Vineberg (1954) use a card sorting procedure in which the subjects classified the cards according to the concept sought by the examiner. The investigators conclude that the differences lie in the success with which subjects are able to verbalize. This result is supported by Heidbreder and Zimmerman's (1955) studies of semantic efficiency. A somewhat different explanation is suggested by Sangstad (1955), who says that the solutions depend on availability of concepts. These three studies are supported by Whorf (1956) who reports a dependence on language which he attributes to the fact that all higher levels of thinking involve language.

However, all the studies do not agree that verbal ability explains differences in strategy. According to Staats (1957) there is no significant relationship between

pre-problem verbal responses and the problem solution, but there is a positive correlation between fluency of verbal responses and the time required to solve the problem. This suggests that fluency of responses better explains differences in strategy than does verbal ability.

Battig (1957) studied differences in strategy through word formation. The subjects were divided according to performance. The upper quarter chose letters according to frequency of usage; the lower quarter tended to use alphabetical order. Harlow (1949) feels that individuals fail to arrive at the concept sought because the correct hypotheses are not available, because they attend to irrelevant hypotheses, and because they use inappropriate strategies. He notes the importance of verbal generalization but emphasizes the fact that subjects use inappropriate strategies. Individual preference and lack of verbal ability are thus suggested as accounting for differences in strategy.

Whatever the reasons for these differences in strategies, it seems to be generally accepted that the differences do in fact exist, and that concept formation tasks may be used to externalize the thinking process. No studies have been done relating concept formation to achievement. Concept formation tasks seem to be more

independent of school learning than intelligence tests and might well, therefore, provide us with a new route to an understanding of the relationship between intelligence and achievement.

The Computer Model.

> A computer can be presented with situations (coded in seven digit numbers) to each of which it responds by printing out a number. Depending on the nature of the response and the nature of the situation, it may or may not receive further consequences, and hence may or may not learn from experience . . . three main subsystems: recognition, emotional reactions, action preparation . . . in addition two memory systems: immediate and permanent, with a learning subsystem that modifies the latter. (Loehlin, 1962)

The computer model takes four phases into account: the input, the memory, the transformation, and the output. The defining characteristics of the computer model fit those of the cognitive process sufficiently well to be useful. The message is coded (input), stored (memory), filtered (transformation) and the response decoded and printed (output). The transformation phase is of particular interest.

> The coded information may be recoded with consequent economy if there are some recurrences, uniformities, or common patterns in the incoming messages. Coded and recoded information is subject to one or more such filters provided that the messages in code continue to have common factors. (Oldfield, 1956)

Oldfield's description of filters, although phrased in different terms, is not unlike Bruner's discussion on

categorizing discriminably different elements as discussed earlier in this chapter.

Newell, Shaw, and Simon (1958) discuss the adequacy of a mechanical model in simulating human problem solving. The program, in the example given, is so constructed that sufficient operations are available to prove theorems in logic using a symbolic system to represent the data. The results are interpreted to mean that problem solving can be explained without recourse to such intangibles as 'insight'.

> The theory rests on two considerations: (1) it shows and in detail how the processes that occur in human problem solving can be compounded out of elementary information processes, and hence how they can be carried out by mechanisms; (2) it shows that a program incorporating such processes, with appropriate organization, can in fact solve problems. This aspect of problem solving has been thought to be "mysterious" and unexplained because it was not understood how sequences of simple processes could account for the successful solution of complex problems. The theory dissolves the mystery by showing that nothing more need be added to the constitution of a successful problem solver. (Newell, Shaw, and Simon, 1958)

More can be learned about the machine's approximation to human problem solving by instructing it to print intermediate results while solving the problem. In the present study the application of an efficiency measure to concept formation tasks is similar to instructing the machine for intermediate results.

Guilford (1961) is convinced that factor analysis can be used profitably to study cognitive-response sequences.

Five problem solving factors are reported: Sensitivity to problems, verbal comprehension, ideational fluency, originality, and conceptual foresight.

The following four assumptions are supported by the studies reviewed in this section:

1. Cognitive functioning can be measured objectively.

> Cognition and thinking can be given entirely objective interpretations for the reason that they have observable referents. (Guilford, 1961)

2. Concept formation tasks effectively externalize the problem solving process.

> We find the same idea applied by J. S. Bruner and his associates to the theory of concept formation. Bruner uses the term strategy, derived from economics and game theory, for what we have called a program. (Newell, Shaw, and Simon, 1958)

3. Creativity is related to problem solving. The creativity instrument used in the present study estimates two of Guilford's factors: ideational fluency and originality.

4. Achievement and intelligence are directly related. Both are cognitive functions which can be adequately simulated by a machine and "nothing more need be added to the constitution of a successful problem solver." (Newell, Shaw, and Simon, 1958)

Neo-Behaviouristic Approach to Cognition. Goss (1955) argues that it is possible to explain cognition from a

behaviouristic viewpoint.

> Conceptual phenomena can be dealt with in stimulus-response terms. A temporal sequence of stimulus-response events in which a mediating response and stimulus may be distinguished can be represented as Stimulus-initiating--Response mediating--Stimulus-mediating--Response terminating. (Goss, 1956)

Kendler and Kendler (1962) also approach problem solving behaviouristically. They investigate the role of mediated S-R events in the formation of problem solving chains. Problem solving is commonly considered outside the realm of S-R experimentation but as Kendler and Kendler point out "there is no one way to investigate problem solving." They report the results of research program based on an S-R model in which the importance of horizontal and vertical processes are emphasized ('horizontal' referring to the linking of S-R responses in a behavioural chain, 'vertical' referring to the assumption that independent chains occur simultaneously). The experiments reported postulate a mediational mechanism within a behavioural chain. They thus imply that it is possible to investigate problem solving in a 'systematic fashion'.

Razran (1961) reviews a number of experiments carried out in the Soviet Union which deal behaviourally with meaning, for example, one experimenter found that the number of saliva drops secreted when approval toned words are presented is greater than the number of drops for words that

suggest disapproval.

Osgood (1960) deals with meaning through a representational mediation process in which a non-significate (U.S.) becomes associated with a significate (C.S.) when accompanied by reinforcement. The C.S. comes to evoke a fractional portion of the total behaviour elicited by the significate, which becomes its meaning and the basis for conceptual generalization. This meaning can be scaled using the semantic differential. A full consideration of the conceptual response, however, must involve a series of responses rather than a single response.

The consensus of opinion is that cognition can be explained through stimulus response theory; moreover, theory suggests two possible approaches to the measurement of cognition. One involves considering the stimulus response sequences obtained through concept formation tasks such as those set by Bruner as a chain of horizontal events in which each S-R in the sequence is a link in the chain of events. As concept formation tasks were discussed at some length earlier in this chapter, attention is now directed to the second approach. The second and preferred approach, because it is embedded in the normal experimental procedures employed generally in science, necessitates controlling an experiment so that only the effect of the variable under study will be reflected in the scores obtained.

The normal scientific approach can be summarized as follows:

1. Identifying a suitable variable for study.
2. Preparing appropriate tests to measure the variable.
3. Selecting a population sample.
4. Controlling related variables.
5. Testing the hypothesis.

Identifying a suitable variable for study involves setting an hypothesis which can be predicted from already established theory. The non-behaviourist, therefore, designs an experiment to test his hypothesis; not to discover an hypothesis.

As both achievement and intelligence are cognitive functions, it seems reasonable to look to further cognitive dimensions to explain the discrepancies between them. Cognition can be defined as a study of the higher mental processes, of which the highest may be the creative process. If intelligence tests measure creativity, or if intelligence and creativity are perfectly correlated, the creativity tests can add nothing to our knowledge of cognitive functioning which is not already available from intelligence tests. However, the widespread interest in creativity, together with the fact that there is reason to believe that creativity and intelligence are not correlated perfectly, lead to the conclusion that creativity might well account for differences in achievement that cannot be accounted

for by intelligence. Creativity, it would seem, is a suitable variable for study.

These ideas are supported, in part, by Guilford (1961) who reports ideational fluency and originality as factors related to problem solving.

> It seems evident that the cognitive abilities assessed by our creativity instruments account for a significant portion of the variance in school achievement. (Getzels and Jackson, 1962)

The statement made by Getzels and Jackson applies to subjects whose measured intelligence places them in the very superior class. The assumptions are that only individuals of superior intellectual ability can be creative, and that creative ability is dependent on a minimum level of intelligence. The assumption in this study, however, is that creativity is possessed in varying degrees by individuals at all levels of ability.

Review of Research on Creativity

Definition of Creativity. Cognition can be defined as a study of the higher mental processes of which the highest is the creative process. One of the most extensive definitions of creativity is that of John Drevdahl (1956).

> Creativity is the capacity of persons to produce compositions, products, or ideas of any sort which are essentially new or novel, and previously unknown to the producer. It can be imaginative activity, or thought synthesis, when the product is not mere summation.

> It may involve the forming of new patterns and combinations of information derived from past experience and the transplanting of old relationships to new situations and may involve the generation of new correlates. It must be purposeful or goal directed, not mere idle fantasy--although it need not have immediate practical application or be a perfect and complete product. It may take the form of an artistic, literary, or scientific production, or may be of a procedural or methodological nature. (Drevdahl, 1956)

Jung (1955) speaks of the "divine gift of creative fire," and its effect on human life. If the personality has a certain fund of energy, says Jung, "the strongest force in him seizes and monopolizes it leaving little for other purposes." He thus explains the ruthlessness, selfishness, and vanity of many creative individuals. Jung's definition suggests that creative individuals feel a 'need' to create.

Weisberg and Springer (1961) defines functional creativity as the:

> Ability to produce, in a given situation, compositions, products, ideas which are essentially new or novel,and previously unknown to the producer. It can be imaginative activity, or thought synthesis, where the product is not a mere summation, It may involve the forming of new patterns and combinations of information derived from past experience, and the transplanting of old relationships to new situations, and may involve the generation of new correlates. It must be purposeful or goal directed, although it need not have immediate application or be a perfect and complete product. (Weisberg and Springer, 1961)

Relationship of Originality to Creativity. Originality and creativity are often confused, the only distinction

made being that the latter is expected to occur less frequently than the former.

> Originality refers to behaviour which occurs relatively infrequently, is uncommon under given conditions, and is relevant to those conditions . . . creativity refers to products of such behaviour and the reactions of other members of society to those products. (Maltzman, 1960)

By this definition one may be highly original and yet not creative. In fact, only the elite few are creative.

Usually originality, defined for measurement purposes as responding in an unusual way, is recognized as an important aspect of creativity.

> Originality . . . responding in an uncommon way as compared to the remainder of the group; producing remote, unusual, and unconventional responses in tests; and exhibiting cleverness in responses as in suggesting story titles when the plot is given. (Wilson, Guilford, and Christensen, 1953)

The Creativity Process. Whatever its nature may be, whether it be a step into a wilderness of thought, a fresh synthesis of familiar material, or a mere shuffling of facts so as to obtain a more understandable relationship, creativity demands intense personal involvement, and because its product must be tested against some standard, it is contingent with critical thinking.

The products of the creative process cause one to speculate about the means by which they come into being. Just as definitions of creativity are many, so are opinions

as to the steps through which the creative individual proceeds.

In an early account, Wallas (1925) formulated four stages, the first of which was a preparatory one in which: "through exposure to the environment, the individual collectedperceptions of his inner and outer world" to be used in the creative process. Whereas a non-creative individual quickly categorizes material and in fact is reluctant to encounter anything he cannot readily accept or understand, the creative person is naive and gullible in his interpretation of events, having little evidence of stereotypy or prejudice. He assimilates life experiences with no intent to categorize or catalogue them for future use. He can tolerate ambiguity to a far greater extent than the conformist.

The second stage is one of incubation in which: "information and experiences mill and flow freely." The larger the quantity of such unassociated data the more likely an association of creative significance is to occur. For the non-creative person, Wallas theorizes, thinking is merely a matter of sorting into recognized compartments.

The third stage is one of illumination or dawning. It is the instant of insight: the "aha" or "Eureka" of creativity.

The fourth stage is verification: the task of communicating the insight and elaborating upon it.

Peter McKellar (1957), writing of conditions necessary to creativity, stresses that the creative individual is receptive towards what others have thought and believed on certain issues, yet critical in a constructive manner. This view is somewhat contrary to the prevalent idea that a creative individual is one who casts all tradition aside and lunges forth independently. Creating is: "recombining ideas during a period of unconscious work in which atoms, previously hooked but now set free, collide and re-unite in new configurations." (McKellar, 1957)

Osborn (1953), in perhaps the most widely read book on creativity, lists seven phases in the process, some of which are similar to those listed by Wallas. They are:

1. Orientation: pointing up the problem.
2. Preparation: gathering pertinent data.
3. Analysis: breaking down the relevant material.
4. Hypothesis: piling up alternatives by way of ideas.
5. Incubation: letting up to invite illumination.
6. Synthesis: putting the pieces together.
7. Verification: judging the resultant ideas.

Taylor (1959) discusses levels of creativity which vary not in type but in depth and scope. These levels,

proceeding from lowest to highest, are:

1. Expressive Creativity--which consists of independent expression, skill, and where the quality of the product is unimportant; for example, children's drawings.

2. Productive Creativity--which involves producing objects which signify mastery of some part of the environment. Greater realism, objectivity, and completeness are requisites.

3. Inventive Creativity--in which ingenuity is exhibited, new and unusual relationships are discovered and ingenious symbolic representation possible.

4. Innovative Creativity--which requires deep searching of established principles so as to make truly meaningful changes. It takes place only when the basic assumptions in a field are sufficiently established to permit modification.

5. Emergentive Creativity--involves the emergence of an "entirely new principle or assumption at a most fundamental and abstract level." Something entirely different may be produced.

Observation of the creative personality may be another way of learning more about the creative process. What sort of person is a creative individual apt to be? Which traits, if any, are more frequently found to be those of creative personalities?

Zilboorg (1959), in writing of the creative personality, sees the creative individual as one who is in "fetters" and trying to get out in order to express himself. Thus the struggle against adversity is part of his nature, and frequently, the harder he must battle to express his talents the greater his accomplishments are. He cannot be standardized, must think things out his own way, and cannot be expected to be objective about his own creations. In some cases severe social maladjustment is accompanied by brilliant creative accomplishment. A person may, because of failure, retreat to one area in which he may develop great proficiency and self-confidence, as did Van Gogh and Beethoven.

Flexibility, alertness, curiosity, and readiness to re-interpret are requisites of creativity.

The majority of persons are "concept-bound theorists who test theories against on-going experiences but cannot focus abilities for action." (Barkan and Hausman, 1956) The creative person must be sensitive to a broad range of possibilities and yet also aware of the necessity for making decisions.

Related Research. Thus far the review of the literature suggests originality and flexibility as two necessary traits of the creative individual. The measurement of creativity assumes its identification, yet it is probably through attempted measures that it may be truly identified.

Guilford is perhaps the foremost worker in attempting to isolate and gauge creativity. Essential to his approach is the conception of the ability as existing on a continuum, permitting the useful study of individuals at all ability levels. In the Wilson, Guilford, and Christensen (1953) study, originality is defined, as previously mentioned, in terms of uncommonness of response, production of remote associations on tests and cleverness of response. In the tests prepared to measure originality, most items are open-ended so as to permit truly creative responses. The reliabilities (some split-half, and some alternate forms) of the seven originality tests range from .53 to .87. They were administered with 46 others, in a battery designed to explore creative thinking, to 410 cadets and student officers, and the results were subjected to factor analysis. Sixteen factors emerged and five of the seven originality test scores emerged with loadings considered significant on one of the factors (.30 or more). The following are the tests, scoring principles and loadings on the factor afterwards labelled originality:

1. Plot Titles - - - - - - cleverness .55
2. Quick Responses - - - - uncommonness .49
3. Figure Concepts - - - - uncommonness .52
4. Unusual Uses - - - - - remoteness .31

5. Association - - - - - - - - remoteness .30

6. Number Association - - - uncommonness .25

7. Association II - - - - - - remoteness .09

A bulletin issued by Guilford, Christensen, Frick, and Merrifield (1957) four years later reports a number of significant correlations between originality and other personality traits. Originality measures are reported positively related to scores on aesthetic expression, meditative thinking, divergent-adaptive thinking, self-confidence, and tolerance.

Meer and Stein (1955) report that the creative function varies significantly with intelligence up to the very superior range of intelligence; above that level there is no correlation between the two factors.

Weisberg and Springer (1961) choose their sample from children whose intelligence is in the gifted range. Because they feel that the closer children are to puberty the greater the danger that any relationship between home environment and the level of creative function may be clouded they choose to work with nine-year-olds. Thirty-two subjects and their families are studied. The creativity tests used are a selected portion of a battery designed by Torrance, using Guilford's factor analytic studies of creative adults. The thinking abilities sought are: Ideational

Fluency--the number of ideas that can be produced; Flexibility--the ability to shift from one idea to another; Originality--ability to produce uncommon ideas; Curiosity--sensitivity to problems in the environment; and Hypothesis Development--ability to make solutional guesses about environmental problems.

The creativity tests used by Weisberg and Springer to measure these abilities include the Tin Can Test, The Circles Test, and the Ask And Guess Test. The results of the experiment describe the optimal home situation of highly creative children as follows:

> It is not an overly close family unit . . . conformity to parental values is not stressed . . . not a particularly well-adjusted marriage . . . sexual adjustment is mediocre . . . there is open, and not always calm expression of strong feeling without that expression being used to bind the child to the values of the parents . . . father interacts strongly and positively with the child . . . mother interacts quite strongly, but tends often to be ambivalent in her maternal feelings . . . father exercises some authority both at work and at home . . . when child regresses, the behaviour is accepted by the parents without discomfort.
> (Weisberg and Springer, 1961)

None of the families tested satisfy all the criteria of the optimal family but all families of the top-scoring children fit most of the patterns as outlined. One other comment with regard to the study just described is noteworthy. In spite of the popular image of the creative person as being independent (having a mind of his own), the tendency for the child to make up his own mind instead

of following the parental lead does not correlate with high test performance. The authors explain this by saying, in effect, that the creative individual must learn to be stubborn and independent if the new idea is to survive an initially hostile atmosphere.

Barron (1955) assumes that "some persons are regularly original, while others are regularly un-original." His experiment is designed to focus attention on "the underlying disposition toward originality which it may be presumed exists in those persons who are regularly original." The subjects chosen, one hundred captains in the United States Air Force, are described as a group of normal, healthy young men, of average intelligence and socio-economically of the lower middle class. Eight free response tests were administered of which the first two--Unusual uses and Consequences--are among the tests used in the present experiment. Originality is defined in terms of uncommonness of response, that is, uncommon in the sample under study and at the same time adequate to the realistic demands of the problem situation. Of the one hundred subjects fifteen are classified as regularly original and fifteen as regularly un-original. "Originality is found to be related to independence of judgment, to personal complexity, and to the preference for complexity in phenomena, to self-assertion and dominance, and finally to the

rejection of suppression as a mechanism for the control of impulse." (Barron, 1955)

In December, 1957, Barron, using the data obtained in the 1955 experiment described above, partials out intelligence and reports that originality scores are significantly related to the following:

a. disposition towards integration of diverse stimuli;
b. energy, fluent output, involvement;
c. personal dominance and self-assertion;
d. responsiveness to impulse and emotion;
e. expressed femininity of interests;
f. general effectiveness of performance.

In the present study of underachievement and overachievement some of the foregoing relationships seem to be directly applicable. For example, if 'general effectiveness' (a mark of the overachiever) is related to originality, then overachievers should score higher than underachievers on originality measures. If, in fact, overachievers score high on originality and if originality is related to 'fluency of output', then overachievers should score higher than underachievers on the Fluency index. Similarly, if originality is related to disposition towards integration of diverse stimuli, then overachievers should be more successful than underachievers on concept formation tasks.

Arnold (1959) states that four features set the product

of creativity apart from that of mere problem solving or decision making. These are:

1. The new combination must be a better solution than previous ones.

2. The solution must be a tangible one, that is, one to which persons react in some way.

3. Creative combination must be forward looking in time rather than an exercise of past solutions.

4. It must be "synergic" or multiplicative in so far as values are concerned. The product is much more valuable than the sum of its components. (Arnold, 1959)

Summary of Observations. A number of observations of importance to the present study can be drawn from the review of the literature on creativity.

1. Creativity is a cognitive function related to intelligence but the correlation is not perfect.

2. A number of creativity tests are available and have been used successfully in recent studies.

3. Evidence justifies the inclusion of creativity in a study of underachievement and overachievement.

4. Some evidence suggests that creativity is related to concept formation.

5. Associations have been found between creativity and various environmental, emotional, motivational, and

personality factors.

An attempt will now be made to synthesize the observations and assumptions drawn from the studies that have been reviewed.

CHAPTER III

ASSUMPTIONS AND HYPOTHESES

Development of Hypotheses

The cognitive processes are defined as the means by which organisms acquire, retain, and transform information.

An assumption basic to this study is that intelligence and achievement are directly related since both are cognitive functions and both are measured by the end products of acquired, retained, and transformed information. It follows from this assumption that the correlation between these two measures of cognition is a function of the degree to which either or both of the measuring instruments sample the cognitive processes.

Psychologists agree that cognitive functioning can be measured objectively but disagree as to instruments that might effectively be used to assess cognition. Neo-behaviourists also disagree with non-behaviourists regarding the approach that should be used to improve the correlation between intelligence and achievement.

Non-behaviourists tend to approach the problem by examining those achievement tests which show the highest correlations with intelligence in an attempt to identify

the factor or factors in the tests that accounts for the higher correlation observed. New items which purport to measure the factor identified are added to the test battery and the test re-administered. If the correlation remains unchanged, the procedure is repeated with some other hypothesized factor. If the correlation is higher, the factor is reported as significant.

Assuming that the factor, so identified, does have a bearing on the problem, there remains the difficulty of explaining why this is so.

The procedures outlined above were applied to the present study. It appears from the literature on concept formation that Bruner type concept formation tasks measure 'some aspect' of cognitive functioning not now measured by by intelligence tests. Similarly achievement tests seem to measure 'something' not included in intelligence tests. Assuming a common factor, other than intelligence, as basic to both concept formation tasks and achievement tests the logical hypothesis is that scores on concept formation tasks will correlate with scores on achievement tasks when intelligence has been partialled out. Should the study support the hypothesis the assumption of a common factor would appear to be justified. However, the identity of the factor might well remain a mystery.

Neo-behaviourists cautiously propose a two stage paradigm to explain central events but they prefer to approach the problem from observables. The procedure followed in the explanation of a problem begins with the isolation of a hypothesized variable. An experiment is designed to control other contributing variables such that any differences in the results can be assumed to have been caused by the uncontrolled variable.

The review of the related research suggests creativity as a suitable variable for investigation. It seems reasonable to hypothesize that creativity will correlate with achievement when intelligence is kept constant. Should the study support this hypothesis creativity is identified as one of the factors that accounts for the discrepancies in achievement not accounted for by intelligence.

Assumptions and Hypotheses

The argument thus far can be briefly summarized as follows:

1. The Problem: An attempt to apply cognitive theory to explain inter-individual differences in achievement.

2. The Assumptions:

   a. Cognitive functioning and achievement are

directly related.

b. Intelligence tests do not adequately measure cognitive functioning.

c. Achievement tests do not adequately measure achievement.

d. Creativity is a cognitive function.

e. Concept formation tasks externalize the cognitive process.

f. Creativity tests are indices of creativity.

3. The Hypotheses:

a. Subjects classified as overachievers, average achievers, and underachievers will show differences in the efficiency with which concept formation tasks are solved.

b. Subjects classified as overachievers, average achievers, and underachievers will show differences in scores on creativity measures.

CHAPTER IV

EXPERIMENTAL SAMPLE AND TESTING INSTRUMENTS

Population Sample

The students constituting the sample for this study were selected from those enrolled in Grade X during the 1961, 1962 school term at the West Jasper Place High School, Edmonton, Alberta. The original total of 275 was reduced to 220 because fifty-five were considered ineligible. Eighteen of these were Indian students and thirty-seven others had not been in attendance at West Jasper Place High School the previous year. It was felt that large variations in cultural background or scholastic training might distort the findings.

A battery of tests (the School and College Ability Test and teacher-made tests in English Literature, English Language, Social Studies, Mathematics, and Science) is administered yearly by the Alberta Department of Education to all Grade IX students. The results form part of the students' permanent records. Senior high school administrators throughout the province use the results of this test battery to group Grade X students, and largely on the basis of these Grade IX results, students are encouraged by guidance counselors to choose one of several high school programs. In

addition, employers use this information to select employees. In this study also, intelligence and achievement ratings were made on the basis of Grade IX standings.

Although intelligence is recognized as accounting for a portion of the variance observed in achievement, the unpredictable proportion is large enough to warrant the hypothesis that other factors must also be responsible. This study, as previously stated, attempts to reveal the existence of additional factors (independent of intelligence) by forming experimental groups on the basis of achievement, with intelligence held constant.

Similarly, it is recognized that sex bears some relation to achievement. Approximately twice as many boys as girls are underachievers; whereas twice as many girls as boys are overachievers. Therefore, the sex variable was also held constant.

Scores on the School and College Ability Test: Level three, (SCAT), the intelligence measure used in the Grade IX test battery, were arranged in stanines on the basis of the school population as illustrated in Table I, page 59. Similarly, students were assigned achievement stanines on the basis of composite achievement scores, the means of their English Literature, English Language, Social Studies, Mathematics, and Science marks with unit weights.

A distribution of the achievement stanines of the population appears in Table II, page 60.

Students whose achievement scores were two or more stanines below their SCAT scores were classified as underachievers; students whose achievement scores were two or more stanines above their SCAT scores were classified as overachievers. Those whose SCAT scores were in the same stanine as their achievement scores were classified as average achievers. Individuals whose SCAT scores were in stanines one, two, eight, or nine thus had to be excluded since no underachievers could be identified in stanines one and two; similarly, no overachievers could be identified in stanines eight and nine.

Three groups matched in intelligence, but differing in relative achievement, as illustrated in Table III, page 61, were formed.

Testing Instruments

A battery of tests comprising eighteen concept formation tasks and six creativity measures was administered to the forty-two subjects. A brief description of each test follows. (The tests are printed in Appendix A)

TABLE I

INTELLIGENCE AND SEX DISTRIBUTION OF POPULATION (N = 220)

		SCAT Stanines									
		1	2	3	4	5	6	7	8	9	Total
SEX	M	2	10	14	22	23	20	14	9	4	118
	F	7	7	13	15	16	22	11	7	4	102
Total		9	17	27	37	39	42	25	16	8	220

TABLE II

ACHIEVEMENT AND SEX DISTRIBUTION OF POPULATION (N = 220)

		Composite Achievement Stanines									
		1	2	3	4	5	6	7	8	9	Total
SEX	M	8	8	14	23	22	16	13	10	4	118
	F	2	6	14	17	21	17	12	10	3	102
Total		10	14	28	40	43	33	25	20	7	220

TABLE III

SEX, INTELLIGENCE STANINE, AND ACHIEVEMENT STANINE OF 42 SUBJECTS IN THREE MATCHED GROUPS: OVERACHIEVERS, AVERAGE ACHIEVERS, AND UNDERACHIEVERS

Overachievers			Average Achievers			Underachievers		
Sex	Scat	Achievement	Sex	Scat	Achievement	Sex	Scat	Achievement
M	7	9	M	7	7	M	7	5
F	7	9	M	7	7	M	7	5
M	6	8	M	6	6	M	6	4
M	6	8	M	6	6	F	6	4
M	6	9	F	6	6	F	6	4
M	5	7	M	5	5	M	5	2
F	5	7	M	5	5	M	5	3
F	5	7	F	5	5	M	5	3
F	5	7	F	5	5	F	5	3
M	4	6	M	4	4	M	4	1
F	4	6	F	4	4	F	4	2
M	3	5	M	3	3	M	3	1
M	3	5	F	3	3	F	3	1
F	3	5	F	3	3	F	3	1

A. Concept Formation Tasks

1. Purpose

These tests attempt to provide a problem solving situation in which the subject receives sequential fragments of information and reacts to each, thus moving closer to the solution of the problem. His responses, therefore, should reveal his pattern of thinking.

2. Test Format

The eighteen concept formation tasks were administered using three sets of eighty-one cards. One set is reproduced in Table IV, page 63, to facilitate explanation.

On each card there are four distinguishing features: a color, a shape, a capital letter, and a small letter. Each of these four attributes can take one of three values. The color attribute has the values of black, red, or green; the figure attribute has the values of square, triangle, or circle; the capital letter attribute has the values of capital A, capital B, or capital C; and the small letter attribute has the values of small a, small b, or small c. In all, there are eighty-one possible different combinations of four attributes.

3. The Tasks

Of the eighteen tasks administered, nine were classi-

TABLE IV

SAMPLE SET OF SYMBOLS APPEARING ON CARDS USED TO ADMINISTER CONCEPT FORMATION TASKS

1.	Bk□Aa	Bk△Aa	Bk○Aa	R□Aa	R△Aa	R○Aa	Gr□Aa	Gr△Aa	Gr○Aa
2.	Bk□Ab	Bk△Ab	Bk○Ab	R□Ab	R△Ab	R○Ab	Gr□Ab	Gr△Ab	Gr○Ab
3.	Bk□Ac	Bk△Ac	Bk○Ac	R□Ac	R△Ac	R○Ac	Gr□Ac	Gr△Ac	Gr○Ac
4.	Bk□Ba	Bk△Ba	Bk○Ba	R□Ba	R△Ba	R○Ba	Gr□Ba	Gr△Ba	Gr○Ba
5.	Bk□Bb	Bk△Bb	Bk○Bb	R□Bb	R△Bb	R○Bb	Gr□Bb	Gr△Bb	Gr○Bb
6.	Bk□Bc	Bk△Bc	Bk○Bc	R□Bc	R△Bc	R○Bc	Gr□Bc	Gr△Bc	Gr○Bc
7.	Bk□Ca	Bk△Ca	Bk○Ca	R□Ca	R△Ca	R○Ca	Gr□Ca	Gr△Ca	Gr○Ca
8.	Bk□Cb	Bk△Cb	Bk○Cb	R□Cb	R△Cb	R○Cb	Gr□Cb	Gr△Cb	Gr○Cb
9.	Bk□Cc	Bk△Cc	Bk○Cc	R□Cc	R△Cc	R○Cc	Gr□Cc	Gr△Cc	Gr○Cc

fied as reception tasks and nine were classified as selection tasks, This division was made on the basis of the manner in which the information was presented.

Reception Tasks. In reception tasks the examiner presented all the information sequentially and told the student whether the card was a positive or negative instance of the concept sought.

The subjects were shown some of the cards and the relevant attributes; for example, color, style of border, or position of eyes, pointed out. A further explanation of the existence of classes of cards which had in common one or more attributes; for example, red cards with a double border, was made. The meaning of the term "positive instance of a class" was thus established. Any card not belonging to a class was classified as a negative instance of that class.

The subjects were now considered adequately prepared to begin the formal testing. The examiner, having chosen a class, presented in random order three positive and three negative instances, the first instance always being positive. The initial positive instance for each of the nine tasks appears in Table V, page 65. The subjects were directed to identify the chosen class and following the presentation of each instance they made an attempt to do so.

TABLE V

INITIAL POSITIVE INSTANCE IN NINE RECEPTION TASKS

Set	Task	In Words	In Code
1	1	Green, Circle, capital B, small b	GOBb
	2	Green, Circle, capital A, small c	GOAc
	3	Red, Triangle, capital C, small c	R△Cc
2	4	Medium, Yellow, Standing, Open Side	MYStOS
	5	Large Blue Flying Open Corner	L.BlFlyOC
	6	Small Blue Flying Closed	S.BlFlyCl
3	7	Fair Hair, Left View, Blue Tie, Both Eyes Open	F.H. LeftBlTBO
	8	Brown Hair, Right View, Blue Tie, Right Eye Open	BrH RightBlT RO
	9	Black Hair, Right View, Red Tie, Right Eye Open	BkH Right RT RO

The student attempted nine tasks, three with each of the three sets of cards. Within a set of three tasks, one class was chosen on the basis of a single attribute, for example, all cards with a capital A. Another was chosen so as to include two attributes, for example, all cards with green, capital B, and a third was chosen so as to include three attributes, as black, capital C, and small c. The tasks involving a single attribute were not necessarily first in the sequence nor was the student made aware that in each set there were three tasks, one including one attribute, a second including two, and a third including three. An attempt was made to randomize the order of presentation within a set. The concepts sought in each of the nine reception tasks appear in Table VI, page 67.

Selection Tasks. A complete set of eighty-one cards was randomly arranged before the subject in nine rows and nine columns for each of the nine selection tasks. (Three tasks for each of three sets of cards). The examiner indicated a positive instance of the concept sought at the outset of each task. The initial positive instances for nine tasks appear in Table VII, page 68. The nine concepts sought appear in Table VIII, page 69.

After the initial presentation of a positive instance the student successively chose cards which the examiner

TABLE VI

CONCEPT SOUGHT IN NINE RECEPTION TASKS

Set	Task	In Words	In Code
1	1	Green, Circle, capital B	GrOB
	2	Capital A	A
	3	Triangle, small c	Δ c
2	4	Medium	M
	5	Large, Blue, Flying	L Bl Fly
	6	Small, Closed Border	S.Cl.
3	7	Fair Hair, Left View	F.H. Left
	8	Blue Tie, Right View, Right Eye Open	Bl T, Right, RO
	9	Red Tie	RT

TABLE VII

INITIAL POSITIVE INSTANCE IN NINE SELECTION TASKS

Set	Task	In Words	In Code
1	1	Black, Triangle, capital B, small a	Bk△Ba
	2	Red Circle, capital C, small b	ROCb
	3	Green Rectangle, capital A, small b	Gr□Ab
2	4	Large, Blue, Flying, Open Side	L. Bl Fly O.S.
	5	Small, Blue, Standing, Closed Border	S.Bl St Cl
	6	Medium, Yellow, Perched, Open Corner	M Y Per OC
3	7	Fair Hair, Blue Tie, Left View, Both Eyes Open	F.H. Bl T Left BO
	8	Brown Hair, Red Tie, Front View, Left Eye Open	BrH RT Front LO
	9	Black Hair, Red Tie, Right View, Left Eye Open	Bk H RT Right LO

TABLE VIII

CONCEPT SOUGHT IN NINE SELECTION TASKS

Set	Task	In Words	In Code
1	1	Black, Triangle, capital B	Bk B
	2	Capital C	C
	3	Rectangle, Small b	□ b
2	4	Large, Flying	L. Fly
	5	Blue Standing, Closed Border	Bl St. Cl.
	6	Open Corner	OC
3	7	Fair Hair, Both Eyes Open	F.H. BO
	8	Brown Hair	Br. H.
	9	Red Tie, Right, Left Eye Open	RT Right LO

identified as being positive or negative instances. After each choice the student made an attempt to identify the concept sought, a maximum of ten trials being permitted. The imposition of a ten-trial limit is further explained in the discussion of the efficiency measure.

Assessment and Scoring Procedures

Three measures, two devised by Bruner (1956) and the other devised by the writer, were employed to evaluate the subjects' responses to the eighteen concept formation tasks.

Wholist-Partist Dichotomy. Bruner (1956) classifies the subject as a wholist if his response contains all the attributes given in the initial instance; and as a partist if the response does not fit the wholist definition.

Correct-Incorrect Dichotomy. Bruner (1956) takes the subject's last response as his final answer because, on occasion, a subject gives the concept sought as a response to an intermediate instance but fails to retain the correct solution as later instances are presented. Accordingly, the subject is considered to have solved the problem correctly only if his final response is the same as the concept sought.

The Lambert Measure of Problem-Solving Efficiency. The two measures used by Bruner fail to take into consider-

ation the complete sequence of responses given by the subject. A third measure is proposed here as a better measure of the efficiency with which an individual solves problems. Briefly, the efficiency score on a task becomes the sum of the efficiency scores on the responses. The score on each response is a product of the value (in terms of tenable hypotheses) assigned to the subject's response and the amount of additional information (in information bits) that the instance provides.

In concept formation tasks the number of variables and the number of attributes are specified. Any combination of attributes constitutes a class; therefore the total number of possible classes is the total number of possible combinations of attributes. Each is a theoretically tenable hypothesis. An untenable hypothesis on the other hand is one which has been nullified by the information presented. For example, given three attributes for each of four variables, there are 255 possible combinations (tenable hypotheses). The presentation of a positive four-attribute initial instance limits the number of tenable hypotheses to fifteen, in that, the class sought must be one of these attributes or a combination of two or more of these attributes. Fifteen hypotheses thus remain tenable; the remainder become untenable.

The next instance presented, whether positive or negative, further limits the number of tenable hypotheses until eventually the class sought is isolated.

The amount of information the subject gains from a card is measured in "bits," an "information bit" being that amount of information which reduces the number of tenable hypotheses by one-half. (Attneave, 1959) For example, three bits of information are required to isolate one class when there are eight tenable hypotheses, ($\log_2 8 = 3$) the first reducing the tenable hypotheses to four, the second to two, and the third establishing a solution.

The tasks in this study each involve 255 tenable hypotheses; 7.994 bits of information are required to isolate the concept sought. (Attneave, 1959) Since in all eighteen tasks the first instance presented was positive which reduced the number of tenable hypotheses to fifteen (in bits 3.907), the amount of information in the initial instance is the difference between 7.994 and 3.907 which is 4.087. All instances were evaluated in this way.

The value assigned to the subjects' responses, on the other hand, was calculated according to the formula $V = T - \frac{U}{T}$ where V is the value of the response, T is the number of tenable hypotheses and U is the number of untenable hypotheses. Examples of assigned values appear in

Table IX, page 74.

The score (S) assigned to a particular response is thus the product of the amount of information in the instance (A) and the value of the subject's response (V), i.e. $S = AV$. The efficiency score Ei for person i on a task is the sum of the scores on each instance, thus $E = \sum_{t=1}^{9} A_t V_{ti}$ where $t = 1, 2 \ldots 9$ instances and $i = 1, 2 \ldots 14$ subjects.

The proposed efficiency measure is a product of two factors, each of which may be affected by chance. The subject may guess at a card or he may guess the correct solution before sufficient information to solve the task has been encountered. Using the proposed efficiency measure a response which is obviously a guess is given a lower efficiency score than a response which utilizes more of the information supplied, even though the guessed response is the concept sought. If the subject were given green-circle capital A small b (GrOAb) as the initial positive instance, the concept sought being capital A, (A) a response green circle capital A small b (GrOAb) is assigned an efficiency score of 61.305; whereas capital A, (A) the correct response, would receive a value of 4.087, the same value as would be assigned to small b, (b) or any other initially presented attribute. Appendix A contains a complete scoring key.

In reception tasks, where the examiner dictates the sequences of instances the chance factor related to instances

TABLE IX

VALUES ASSIGNED TO A SAMPLE OF INITIAL RESPONSES

Instance	Positive or Negative	Response	Number of Tenable Hypotheses	Number of Untenable Hypotheses	Value T-U/T
Gr O Bb	Positive	Gr O Bb	15	0	15
		Gr O Ba	7	8	5 6/7
		Gr O Aa	3	12	-1
		Bk O Ac	1	14	-13
		Gr O B	7	0	7
		Gr O A	3	4	1 2/3
		Gr O	3	0	1
		Bk O	1	2	-1
		O	1	0	1
		A	0	1	-1
Bk O Ba	Positive	Gr O Bb	3	12	-1
		Gr O Ba	3	12	-1
		Gr O Aa	1	14	-13
		Bk O Ac	1	14	-13
		Gr O B	3	4	1 2/3
		Gr O A	1	6	-5
		Gr O	1	2	-1
		Bk O	1	2	-1
		O	1	0	1
		A	0	1	-1

is not operative. However, in selection tasks the subject chooses the instances and chance may affect the amount of information made available by his choices. Assuming the subject is a conservative focusser (one who changes one attribute at a time), he may vary one of four attributes on his first choice. If the attribute varied is not contained in the concept sought, the instance is positive, and he receives maximum information; whereas, if the attribute he varies is contained in the concept sought, the instance is negative and does not provide maximum information, although a negative instance may be informative to some extent if it reduces the number of tenable hypotheses.

In both cases this subject is appropriately applying the conservative focussing strategy. Consequently the efficiency scores should be the same, but the effects of chance are such that the efficiency scores differ and the maximum score varies from task to task and from individual to individual on a given task.

The number of choices required to isolate a concept on any given task may vary from one to eight, therefore the imposition of a list of ten choices seemed reasonable and proved to be adequate. The wide variation in the number of choices required to solve the problem is attributable in part to chance as described above, and in part to the

efficiency with which the individual uses the information. A correction is, therefore, necessary to make individual scores on a given task comparable. Two scores were computed from each subject's sequence of choices on a given task: The subject's actual efficiency score (computed from the subject's actual responses as indicated above, page 74) and an optimal score computed from the 'best' responses possible, that is, from a set of responses that utilized all the information as it became available. Corrected efficiency scores were calculated by applying the formula $E_c = \frac{100A}{P}$; where E_c is the corrected efficiency score, A is the subject's actual score and P is the optimal score. The corrected efficiency score is a measure of the efficiency with which the individual utilizes that information which is available, the chance effects attributable to the instances chosen being reduced to a minimum.

(d) Reception Task Two Marking Key and Sample Responses as Evaluated.

The initial positive instance oresented in Reception Task Two was green circle capital A small c and the concept sought was capital A. (GrOAc). The marking key for this task appears in Table X, page 77. The sequence of positive and negative instances was presented in the order indicated in Table X reading from left to right. Each attribute in the subject's response is indicated by a plus or minus sign (plus

TABLE X

RECEPTION TASK TWO MARKING KEY (CONCEPT SOUGHT: A)

Instance		Gr O Ac	Gr□Ac	Bk□Bc	R□Bc	Bk O Cb	R O A a
Positive or Negative Responses		Positive	Positive	Negative	Negative	Negative	Positive
++++	15	61.305	16.500	3.330			
+++-	5.86	23.938	6.443	1.300			
+ --	-1	-4.087	-1.100	-.222			
+---	-13	-53.131	-14.300	-2.886			-33.605
+++	7	28.609	7.700	1.554			
++-	1.67	6.812	1.833	.370			4.308
+--	-5	-20.435	-5.500	-1.110			-12.325
---	-7	-28.609	-7.700	-1.554			
++	3	12.261	3.300	.666			
+-	-1	-4.087	-1.100	-.222			
--	-3	-12.261	-3.300	-.666			
+	1	4.087	1.100	.222			2.585
-	-1	-4.087	-1.100	-.222			
Information Bits		4.087	-1.100	.222	0	0	2.585

Example 1.

Instance Presented		Response Given	Response	Value	Information Bits	Efficiency Score
Gr O Ac	(P)	O A	++	3	4.087	12.261
Gr Ac	(P)	G A	++	3	1.100	3.300
Bk Bc	(N)	G A	++	3	.222	.666
R Bc	(N)	G A	++	3	0	0
Bk O Cb	(N)	G A	++	3	0	0
R O Aa	(P)	A	+	1	2.585	2.585
			Total Efficiency Score			18.812

Example 2.

Instance Presented		Response Given	Response	Value	Information Bits	Efficiency Score
Gr O Ac	(P)	A	+	1	4.087	4.087
Gr Ac	(P)	Gr A	++	3	1.100	3.300
Bk Bc	(N)	Gr A	++	3	.222	.666
R Bc	(N)	Gr Ac	++_	1.67	0	0
Bk O Cb	(N)	Gr Ac	++-	1.67	0	0
R O Aa	(P)	R Aa	+--	-5	2.585	12.925
			Total Efficiency Score			-4.872

Example 3.

Instance	Presented	Response	Response	Value	Information Bits	Efficiency Score
Gr O Ac	(P)	Gr	+	1	4.087	4.087
Gr □ Ac	(P)	Gr	+	1	1.100	1.100
Bk □ Bc	(N)	A	+	1	.222	.222
R □ Bc	(N)	A	+	1	0	0
Bk O Cb	(N)	A	+	1	0	0
R O Aa	(P)	A	+	1	2.585	2.585
			Total Efficiency Score			7.994

Example 4.

Instance	Presented	Response	Response	Value	Information Bits	Efficiency Score
Gr O Ac	(P)	Gr O Ac	++++	15	4.087	61.305
Gr □ Ac	(P)	Gr Ac	+++	7	1.100	7.700
Bk □ Bc	(N)	Gr Ac	+++	7	.222	1.554
R □ Bc	(N)	Gr Ac	+++	7	0	0
Bk O Cb	(N)	Gr Ac	+++	7	0	0
R O Aa	(P)	A	+	1	2.585	2.585
			Total Efficiency Score			73.144

Example 5.

Instance	Presented	Response	Response	Value	Information Bits	Efficiency Score
Gr O Ac	(P)	Gr O A	+++	7	4.087	28.609
Gr □ Ac	(P)	Gr A	++	3	1.100	3.300
Bk □ Bc	(N)	Gr A	++	3	.222	.666
R □ Bc	(N)	Gr A	++	3	0	0
Bk O Cb	(N)	Gr A	++	3	0	0
R O Aa	(P)	A	+	1	2.585	2.585
			Total Efficiency Score			35.160

(e) Selection Task Two and Sample Responses as Evaluated

The Selection Task marking key, included in Appendix (C . page 215) is too long to reproduce here. A few sample responses will clarify the marking procedures used. The concept sought in Selection Task Two was capital "C" and the initial positive instance presented was R O Cb.

Example 1.

Instance	Subject's Response	Value	Information Bits	Actual Score	Optimal Response	Value	Optimal Score
ROCb	(P) Cb	3	4.087	12.261	ROCb	15	61.305
Gr∆Cb	(P) Cb	1.67	2.322	3.870	Cb	3	6.966
Gr O Cb	(P) Gr Cb	1.67	0	0	Cb	3	0
Gr O Cb	(P) Gr C	-1	0	0	Cb	3	0
Gr □ Ca	(P) Gr	-1	1.585	-1.585	C	1	1.585
	Total Actual		14.546		Total Optimal		69.856

Corrected Efficiency Score $\frac{14.546}{69.856} \times 100 =$ 20.823

Example 2.

Instance	Subject's Response	Value	Information Bits	Actual Score	Optimal Response	Optimal Value	Optimal Score
ROCb	(P) ROC	7	4.087	28.609	ROCb	15	61.305
ROCa	(P) ROC	7	1.100	7.700	ROC	7	7.700
ROCc	(P) ROC	7	0	0	ROC	7	0
GrOCa	(P) OC	3	1.222	3.666	OC	3	3.666
GrOAb	(N) OC	3	.585	1.755	OC	3	1.755
Gr Cc	(P) C	1	1.000	1.000	C	1	1.000
	Total Actual		42.730		Total Optimal		75.426

Corrected Efficiency Score $\frac{42.730}{75.426} \times 100 =$ 56.652

Example 3.

Instance	Subject's Response	Value	Information Bits	Actual Score	Optimal Response	Value	Optimal Score
ROCb (P)	ROCb	15	4.087	61.305	ROCb	15	61.305
ROCa (P)	ROC	7	1.100	7.700	ROC	7	7.700
ROAc (N)	ROC	7	.807	5.649	ROC	7	5.649
BΔCb (P)	C	1	1.000	1.000	RC	3	3.000

Total Actual 75.654 Total Optimal 77.654

Corrected Efficiency Score $\frac{75.654}{77.654} \times 100 =$ 97.424

Example 4.

Instance	Subject's Response	Value	Information Bits	Actual Score	Optimal Response	Value	Optimal Score
ROCb (P)	RO	3	4.087	12.261	ROCb	15	61.305
Gr O Aa (N)	Oa	-1	.100	-.100	ROCb	15	1.500
RO Ba (N)	a	-3	.222	-.666	ROCb	15	3.330
R □ Ab (N)	RO	-3	.263	-.789	ROCb	15	3.945
Bk□Cc (P)	Rc	-3	3.322	-9.966	C	1	3.322

Total Actual .74 Total Optimal 73.402

Corrected Efficiency Score $\frac{.74}{73.402} \times 100 =$ 1.008

if the attribute is still tenable and minus if the attribute is no longer tenable). All possible combinations of four or fewer attributes and the value assigned to each are given. The amount of information available from each instance is also indicated. The figures given in the body of the table are products of the value of the responses and the number of information bits for any given response on any given instance in this task. Marking keys for all nine reception tasks were calculated in the same way and appear in Appendix C. The following examples are given to illustrate the marking procedures used.

B. Creativity Tests

1. Purpose

The following instructions were given for the creativity tests:

> This booklet contains several tasks which will require you to use your imagination. There are no 'correct' or 'incorrect' answers in the usual sense. There are many possible answers or solutions to each problem. In most cases you will be asked to think of as many possible solutions as you can. Do not be afraid to guess or to put down the ideas which you think up. You are urged to think of solutions which have never been thought of before.

From these instructions one ascertains that creativity tests are designed to estimate the relative facility with which an individual meets a new (to him) situation.

2. The instruments

A number of tests designed to measure creativity are available. (Getzels and Jackson, 1962, p. 198; Yamamoto, 1962, p. 4).

Although the battery selected for use in this study is printed in Appendix A, page 180, task one is introduced here for discussion purposes. The subject is told: "List below the cleverest, most interesting, and most unusual ways you can think of for changing the toy dog you will be shown so that children would have more fun playing with it." The five minute time limit seems adequate for the majority of the subjects.

3. Marking Procedures

Four scores, Fluency, Flexibility, Originality, and Elaboration are derived from the results of the tests.

a. A Fluency score is obtained by counting the number of responses given, excluding only those which are irrelevant or repeated.

b. The Flexibility score is obtained by counting the number of 'runs' revealed in responses in terms of the principles. The principles vary from task to task. In task I they are manipulation, alteration, and dynamism.

(i) Manipulation includes changes in accessories, Color, orientation number.

(ii) Alteration includes changes in dimensions, design, materials use, and kind.

(iii) Dynamism is based on any operation which animates the toy giving it eye appeal, ear appeal, or motion. In task II the three principles are ornamental-household,

container, holder and scientific-mechanical. In task III the principles are life-nature, ornamental-household, and scientific-mechanical.

c. Originality scores are obtained by summing the weighted scores given each response according to the principles used in defining the flexibility score.

d. Elaboration is given a score of one or two. To obtain a score of two, a response must indicate specifically the purpose of the change, the method to be employed in making the change or the materials with which the change is to be effected.

The following examples are given to clarify actual scoring procedures. In the sequence of four symbols used for coding a response the first symbol stands for Fluency; the second, for Flexibility; the third, for Originality; and the fourth, for Elaboration.

Example 1. (Fluency 7; Flexibility 2; Originality 13; Elaboration 9)

Response: 1. Make it walk - - - - - - - - - - - 1D12
2. Lengthen the tail - - - - - - - - 1A21
3. Put it on wheels - - - - - - - - - 1A21
4. Bigger eyes - - - - - - - - - - - 1A21
5. Bigger nose - - - - - - - - - - - 1A21
6. Rubber tip on the nose - - - - - 1A22
so it will feel wet
7. Removable spots - - - - - - - - - 1A21

Since each of the seven responses suggest a different change, each is valued at one on the fluency index. A response such as "Larger eyes" added as an eighth response would not change the score because this change is suggested in response four. Only the first response suggests a change that would add a mechanism within the toy dog making it dynamic. The other six choices are merely structural changes, classified as 'alteration'. The flexibility score for this sequence of responses is two. Had the subject changed the order of his responses such that the first response became his second, third, fourth, fifth or sixth response the flexibility score would have been three because the first run would have been structural changes, the second a dynamic change and the third structural changes. Originality scores are weighted according to the percentage of responses made by the 594 students on whom the test was standardized. Responses given by more than fifteen per cent of the population are valued at one; responses given by more than five per cent but less than fifteen per cent of the population are valued at two; and the responses given by less than five per cent of the population are valued at three. (Yamamoto, 1962, p. 18) Each response receives a minimum elaboration score of one. The maximum score possible is two, which is given when the purpose of the change is given; for example, response six: "rubber tip on the nose so it will feel wet."

Response 1. Put wheels on it so it can be pulled - 1A22

2. Put a barking device inside the dog so it can bark when squeezed - - - - 1D22

3. Build the dog so that the head could move up or down - - - - - - - - - - 1A22

4. Make the eyes blink when the head is moved - - - - - - - - - - - - - 1D22

Example 2. (Fluency 4; Flexibility 4; Originality 8; Elaboration 8)

Response 1. Straighten out its head - - - - - - - 1M31

2. Make it larger - - - - - - - - - - - - 1A21

3. Put a non-tearable skin on it - - - - 1A22

4. Give it moveable eyes - - - - - - - - 1A21

5. Give it a mechanical bark - - - - - - 1D22

6. Give it eyes that light up - - - - - 1D11

7. Put on a real looking collar - - - - 1M11

8. Have a leash - - - - - - - - - - - - 1M11

9. Put rollers or wheels on it - - - - - 1A21

10. Change the black spots to white spots 1M32

11. Give it blue eyes that shine - - - - 1M32

12. Curl its tail - - - - - - - - - - - - 1A21

13. Make one eye red and the other black 1M32

Example 3. (Fluency 13; Flexibility 8; Originality 27; Elaboration 18)

Further examples are given in Appendix A, page

BIBLIOGRAPHY

CHAPTER V

ANALYSIS OF THE DATA

Statistical analyses were carried out to determine the extent to which the test results would give support to the hypotheses as stated in Chapter III. The first hypothesis dealt with the relationships between achievement scores and scores on concept formation tasks; the second dealt with the relationships between achievement scores and scores on creativity tests. They will be considered separately.

Achievement and Concept Formation

Eighteen concept formation tasks were administered as outlined in Chapter IV, and the resulted obtained were analyzed. Because of the differences between reception and selection tasks the analysis relating to the first hypothesis must be divided into two sections.

A. Reception Task Results

The efficiency scores obtained from the results of the reception tasks are reported in Tables XI, XII, and XIII. The methods used in quantifying the data seemed adequate to meet the assumptions of conventional analysis

TABLE XI

RAW SCORES ON RECEPTION TASKS OBTAINED BY UNDERACHIEVERS

Student Number	Tasks 1	2	3	4	5	6	7	8	9	Total
101	11.78	7.99	17.81	16.67	13.67	20.98	20.98	14.81	21.61	146.21
102	28.68	35.16	39.44	37.16	31.29	42.62	34.07	29.24	17.98	295.63
103	65.67	14.53	77.89	69.86	79.74	76.11	77.89	83.45	70.65	615.79
104	11.78	2.38	3.82	26.18	18.28	20.98	14.64	11.23	17.98	127.28
105	62.56	65.31	68.74	66.69	75.35	64.81	75.31	77.56	70.65	626.99
106	57.98	72.26	71.15	69.86	65.93	70.43	63.69	59.44	70.65	601.39
107	59.98	67.86	64.21	62.04	67.73	64.81	57.75	59.63	70.65	574.67
108	6.32	2.38	10.21	4.82	5.20	4.55	4.99	2.41	7.99	448.88
109	12.83	18.93	20.98	29.35	6.84	25.47	41.33	24.34	11.98	192.05
110	4.77	12.73	20.34	29.35	14.99	30.22	17.58	26.96	67.03	233.69
111	11.80	-27.32	-24.19	11.87	-.81	66.72	4.14	55.16	28.65	126.03
112	4.97	-7.99	-9.16	-42.03	-.30	-33.47	.37	-15.70	11.58	-91.74
113	6.39	3.58	29.70	5.18	7.07	42.62	22.55	32.94	67.03	217.06
114	14.50	7.55	6.35	20.18	13.17	11.35	16.52	6.75	11.98	108.99
Mean	25.71	19.66	28.34	29.08	28.44	35.59	32.27	33.44	39.03	

TABLE XII

RAW SCORES ON RECEPTION TASKS OBTAINED BY AVERAGE ACHIEVERS

Student Number	Tasks									
	1	2	3	4	5	6	7	8	9	Total
201	31.68	21.91	30.10	24.68	65.53	76.11	66.86	69.44	67.04	453.34
202	2.77	15.04	37.33	37.16	30.82	72.44	42.62	43.56	37.96	319.70
203	24.82	33.92	-38.01	-30.02	61.29	20.09	42.62	24.86	12.53	152.12
204	49.26	36.70	65.26	38.38	61.17	68.38	70.41	15.81	27.62	432.97
205	59.98	73.14	72.74	66.69	37.36	74.11	77.89	83.46	64.65	610.03
206	59.58	15.84	20.98	37.16	31.71	34.56	77.89	30.90	33.29	341.91
207	4.05	.18	4.50	7.99	5.20	4.35	6.99	1.77	7.99	43.02
208	63.14	67.87	62.40	69.86	65.13	76.11	70.03	22.90	70.65	568.08
209	27.90	5.47	68.96	63.52	22.77	66.68	22.26	36.41	27.13	341.07
210	13.24	7.99	2.82	24.70	18.28	19.35	17.81	7.42	17.98	129.61
211	6.77	2.38	5.18	4.82	13.75	4.72	6.35	1.77	7.79	53.53
212	30.17	19.65	75.78	22.98	79.74	76.11	28.20	69.56	33.29	435.48
213	30.17	66.20	37.93	33.99	37.38	13.01	72.09	19.12	21.61	331.51
214	28.22	2.30	20.11	-10.44	61.66	17.11	60.78	30.51	-4.04	206.21
Mean	30.84	26.32	33.29	27.96	42.27	44.51	47.34	32.68	31.20	

TABLE XIII

RAW SCORES ON RECEPTION TASKS OBTAINED BY OVERACHIEVERS

Student Number	Tasks 1	2	3	4	5	6	7	8	9	Total
301	8.60	22.51	17.81	37.16	30.82	32.12	70.21	33.92	70.65	323.79
302	63.14	73.14	68.13	69.86	79.74	64.81	29.49	21.62	37.96	507.88
303	63.14	73.14	77.89	69.86	79.74	76.11	77.89	83.46	70.65	671.88
304	25.29	33.50	32.27	69.86	79.74	76.11	77.89	83.46	70.75	548.76
305	-29.74	73.14	69.59	52.75	65.61	69.94	69.28	74.09	67.03	511.68
306	29.21	40.45	15.38	20.81	9.53	20.98	20.98	25.57	34.33	217.24
307	32.53	35.23	42.61	66.69	29.96	20.98	20.98	22.07	28.33	299.43
308	59.98	73.14	77.89	69.86	67.73	64.81	66.86	60.27	71.65	611.19
309	63.14	73.14	77.89	69.85	79.74	66.89	77.89	79.66	70.65	658.85
310	14.94	17.48	42.61	17.64	19.48	31.39	24.98	27.23	15.61	211.36
311	64.63	30.49	71.48	60.35	69.52	70.43	62.21	66.61	70.65	566.36
312	11.79	2.91	14.59	4.47	25.91	16.08	13.67	1.94	16.33	107.69
313	11.87	1.92	28.36	35.21	68.90	49.01	62.53	69.85	57.49	358.15
314	17.12	29.99	41.33	33.99	23.12	26.27	37.33	19.23	11.98	240.35
Mean	31.11	41.44	48.42	48.46	52.11	49.00	50.87	47.78	50.43	

of variance techniques. Since the assumption that the efficiency scores could be considered on an interval scale was somewhat dubious, it was deemed advisable to consider the data as if they were on an ordinal scale. The coefficient of intraclass correlation (Haggard, 1958) for data in the form of ranks was calculated using two-way analysis of various procedures. The coefficient of intraclass correlation is the measure of the relative homogeneity of the scores within a class in relation to the total variation among all the scores in a table. The statistic is based on the assumption that there is no interaction between columns and rows, so that the total variation is attributable to three sources: (1) column means; (2) row means; and (3) residual. The data are arranged in a matrix such that the column means are equal. This procedure holds one variable constant while studying the effects of the other. In algebraic form the variable held constant has a zero sum of squares as shown in the summary of analysis. The procedure can be repeated reversing columns and rows thereby holding constant the other variable under study. The analysis revealed no significant differences among tasks when groups were held constant but it did reveal significant differences among groups when tasks were held constant. A summary of the analysis is given in Table XIV, page 93.

TABLE XIV

SUMMARY OF ANALYSIS OF VARIANCE OF RECEPTION TASKS--RANKED

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Problems Ranked c-9;k-3						
Total	180	26				
Problems	84	8	10.50	1.75	.200	Not Significant
Groups	0	2				
Groups and Problems	96	16	6			
Groups Ranked c-3;k-9						
Total	18	26				
Groups	14	2	7	28.00	.75	.01(F_r .01 is 7.05 R_r .01 is .402)
Problems	0	8				
Groups and Problems	4	16	.25			

The overachievers achieved the best results on reception tasks; the average achievers did less well than the overachievers but much better than the underachievers.

B. Selection Task Results

In scoring selection tasks an actual score and an optimal score were obtained for each subject on each task. The optimal score varied from task to task and from subject to subject. It was necessary, therefore, to adjust the actual score before comparisons were made. An individual's actual score on a task was divided by his optimal score on that task and the results multiplied by 100. The corrected efficiency scores derived in this way are given in Tables XV, XVI, and XVII. The coefficient of intraclass correlation (Haggard, 1958) for data in the form of ranks was calculated using two-way analysis of variance procedures. A summary of the analysis is given in Table XVIII, page 98.

The findings indicate that significant differences at the .05 level exist among tasks and among groups. On examining the data it appeared that the ninth selection task was more difficult for all subjects. To check this observation the remaining eight problems were ranked and R_r computed. The results of this analysis, summarized in Table XIX, page 99, indicated that no significant difference exists among the eight tasks, confirming the ninth

TABLE XV

CORRECTED EFFICIENCY SCORES ON SELECTION TASKS OBTAINED BY UNDERACHIEVERS

Student Number	Tasks 1	2	3	4	5	6	7	8	9	Total
101	22.55	23.09	24.92	20.00	21.95	-10.67	20.79	21.45	-6.31	137.75
102	46.67	26.46	7.79	18.22	9.21	.69	18.17	10.43	15.22	152.86
103	100.00	100.00	100.00	31.88	39.77	47.62	100.00	98.43	31.58	649.27
104	30.66	34.57	20.00	52.37	10.69	19.51	21.76	25.26	41.91	256.72
105	34.19	7.83	41.82	50.31	46.67	46.67	46.34	43.59	38.02	355.44
106	100.00	82.57	100.00	24.90	36.22	38.52	48.65	53.20	24.90	508.95
107	5.45	-12.53	1.46	19.64	39.70	16.81	20.00	4.32	15.21	110.06
108	2.94	5.10	5.64	5.10	5.10	6.67	5.47	6.67	7.31	49.99
109	21.95	40.97	23.75	10.60	1.18	-58.34	20.00	1.19	-10.39	50.91
110	16.32	24.06	25.34	39.50	46.67	14.72	46.72	25.26	25.46	261.04
111	12.46	29.14	19.49	17.60	9.61	46.03	32.45	21.36	8.47	196.61
112	1.90	39.20	24.74	25.07	20.89	-4.10	10.99	.90	-7.94	111.66
113	27.57	31.34	38.42	21.01	19.17	38.75	51.86	48.34	-3.90	272.56
114	28.93	14.60	18.34	27.94	11.72	20.53	20.00	14.14	1.13	157.32
Mean	32.36	31.89	32.27	26.01	22.75	15.94	33.09	23.90	12.91	

TABLE XVI

CORRECTED EFFICIENCY SCORES ON SELECTION TASKS OBTAINED BY AVERAGE ACHIEVERS

Student Number	Tasks 1	2	3	4	5	6	7	8	9	Total
201	28.93	20.82	83.19	29.52	17.20	22.39	27.65	51.21	21.74	302.66
202	46.67	56.65	13.74	30.45	29.91	45.59	22.55	45.59	23.79	314.93
203	-26.95	9.29	59.80	17.04	12.14	9.32	11.02	23.97	-13.04	102.59
204	46.67	41.07	17.37	6.32	22.93	39.17	11.02	23.09	9.63	217.26
205	100.00	97.42	66.60	55.01	16.78	23.63	55.22	23.09	29.51	467.26
206	10.43	1.01	52.11	39.34	29.72	46.21	40.08	22.20	-1.91	239.18
207	5.00	7.76	1.01	55.01	36.86	37.88	32.84	20.00	20.98	217.33
208	11.87	-11.16	2.94	16.19	17.08	19.03	10.20	30.28	2.43	98.85
209	46.67	29.72	16.97	14.44	46.67	1.81	25.75	38.58	5.24	225.84
210	8.24	18.02	20.00	9.32	14.42	52.11	36.04	-7.22	13.33	164.26
211	2.66	5.69	2.43	30.65	40.28	50.36	32.17	50.16	7.01	221.41
212	77.09	98.28	98.28	32.95	13.89	-4.92	13.53	39.54	34.43	403.07
213	46.67	43.64	40.70	22.97	42.19	40.54	34.56	44.00	22.97	338.23
214	6.13	.83	12.56	24.02	36.87	11.75	33.24	33.88	12.23	171.49
Mean	29.29	29.93	38.84	27.37	26.92	28.21	27.56	31.31	13.45	

TABLE XVII

CORRECTED EFFICIENCY SCORES ON SELECTION TASKS OBTAINED BY OVERACHIEVERS

Student Number	Tasks 1	2	3	4	5	6	7	8	9	Total
301	18.35	32.49	16.66	3.41	29.83	36.81	14.68	21.50	7.59	181.31
302	12.64	45.59	40.17	46.24	46.67	98.73	20.55	25.96	10.47	347.02
303	100.00	100.00	61.97	55.01	46.67	49.94	55.06	14.57	1.33	484.53
304	28.93	18.42	14.12	22.97	46.67	48.84	46.34	53.20	26.52	306.00
305	9.50	55.32	34.82	27.82	46.67	34.56	43.15	33.27	31.09	316.19
306	24.84	20.19	20.00	36.84	31.95	21.77	26.38	45.59	11.54	239.10
307	21.95	12.06	16.21	7.94	35.91	52.13	14.30	7.82	16.56	184.88
308	19.36	83.05	86.35	49.72	37.37	49.46	26.97	55.97	46.67	454.92
309	42.20	50.59	41.82	39.65	38.60	38.01	20.00	53.20	11.33	335.39
310	18.47	18.20	38.76	27.27	12.61	25.26	.60	28.03	46.21	215.39
311	9.51	23.26	34.01	3.90	10.79	22.36	28.93	18.55	8.45	159.86
312	28.93	5.36	28.16	26.46	5.51	9.31	18.30	21.14	6.73	149.89
313	72.29	53.70	46.67	46.67	46.67	34.50	44.72	39.30	38.37	422.89
314	3.37	12.48	17.58	18.30	12.74	7.44	22.67	18.69	5.58	111.85
Mean	29.31	37.91	35.52	29.44	32.05	37.79	27.33	31.20	19.17	

TABLE XVIII

SUMMARY OF ANALYSIS OF VARIANCE OF SELECTION TASKS--RANKED

Source Variance	S.S	df	M.S.	F_r	R_r	Level of Significance
Problems Ranked						
c-9;k-3						
Total	180	26				
Problems	105.33	8	13.166	2.82	.38	.05 (F_r is 2.59)
Groups	0	2				
Problems and Groups	74.666	16	4.66			
Groups Ranked						
c-3;k-9						
Total	18	26				
Groups	6.2222	2	3.111	4.23	.264	.05(F_r is 4.00 or R_r is .25)
Problems	0	8				
Groups and Problems	11.77777	16	.736			

TABLE XIX

SUMMARY OF ANALYSIS OF VARIANCE OF EIGHT SELECTION TASKS--RANKED

Source of Variance	S.S	df	M.S.	F_r	R_r	Level of Significance
Problems Ranked 6-8;K-3						
Total	126	23				
Tasks	51.333	7	7.333	1.375	.111	Not Significant (F_r is .277)
Groups	0	2				
Groups and Tasks	74.666	14	5.333			

task as different from the other eight tasks.

The initial positive instance presented in the ninth task was black hair, red tie, right view, and left eye open and the concept sought was red tie, right view and left eye open. The greater difficulty observed would appear to be the result of the use of right and left as attributes of two different variables, particularly because left eye open and right eye open referred to the position of the eye in the face while left view and right view referred to the face as seen by the subject.

The results of the analysis supported the first hypothesis. The three groups selected on the achievement dimension performed differently on both reception and selection tasks. These results were interpreted to mean that concept formation tasks measure some aspect of cognitive functioning which is useful in school success and which is not measured to the same degree by intelligence tests.

Achievement and Creativity

The results obtained on the four creativity indices; Fluency, Flexibility, Originality, and Elaboration are given in Table XX, page 101. The numbers 101 to 114, 201 to 214, 301 to 314, identify subjects in the underachievement, average achievement, and overachievement groups respectively. The discriminant function (Kendall, 1948), calculated on the basis of three matrices given in Table XXI, page 103, was used to

TABLE XX

RAW SCORES OBTAINED ON CREATIVITY TESTS

Subject Number	Fluency	Flexibility	Originality	Elaboration	Total
101	25	10	50	28	113
102	19	11	37	19	86
103	14	12	38	21	85
104	29	14	49	37	129
105	18	11	28	21	78
106	36	14	40	29	119
107	33	13	66	43	155
108	17	8	36	32	93
109	33	15	53	40	141
110	11	6	20	13	50
111	28	15	57	32	132
112	14	4	25	16	59
113	22	8	37	24	91
114	26	14	44	36	120
Total	325	155	580	391	1,451
Mean	23.21	11.07	41.43	27.93	103.64

TABLE XX (continued)

Subject Number	Fluency	Flexibility	Originality	Elaboration	Total
201	31	13	50	45	139
202	46	26	87	65	224
203	28	15	55	33	131
204	43	20	87	62	212
205	32	13	55	41	141
206	26	15	51	39	131
207	20	7	32	20	79
208	32	15	39	34	120
209	27	12	44	32	115
210	22	15	46	24	107
211	37	13	55	44	149
212	25	11	44	31	111
213	32	15	55	40	142
214	38	14	63	51	166
Total	439	204	763	561	1,967
Mean	31.36	14.57	54.50	40.07	140.50

Subject Number	Fluency	Flexibility	Originality	Elaboration	Total
301	29	15	54	40	138
302	24	18	49	29	120
303	42	20	78	58	198
304	54	23	112	71	260
305	36	15	54	39	144
306	29	16	51	37	133
307	42	21	79	50	192
308	42	17	73	55	187
309	33	17	68	42	160
310	13	7	30	17	67
311	23	11	57	44	145
312	23	13	41	28	105
313	49	18	100	63	230
314	30	17	50	33	130
Total	479	228	896	606	2,209
Mean	34.21	16.29	64.00	43.29	157.79

TABLE XXI

SUMS OF SQUARES AND CROSS PRODUCTS ABOUT THE MEANS FOR FOUR MEASURES OF CREATIVITY ON PAIRS OF GROUPS

		Fluency	Flexibility	Originality	Elaboration	Mean Differences
Underachievers and Overachievers	Fluency	3230.61				11.00
	Flexibility	1144.92	563.01			5.22
	Originality	9748.49	2184.96	12330.37		22.57
	Elaboration	4026.83	1441.95	7958.91	5616.98	15.36
Underachievers and Average achievers	Fluency	2027.17				8.15
	Flexibility	807.98	489.17			3.50
	Originality	7038.80	1519.28	6574.48		13.07
	Elaboration	2681.92	1173.35	4903.08	4302.00	12.14
Average achievers and Overachievers	Fluency	2342.85				2.85
	Flexibility	815.41	481.62			1.72
	Originality	4628.39	1821.63	10531.25		9.50
	Elaboration	3327.76	1194.57	6872.88	5088.77	3.22

compare the results of the three achievement groups on four measures of creativity.

In matrix form the equation $\underline{SW} = \underline{D}$ where $\underline{S}$ is the 4 x 4 matrix of sums of squares and cross products about respective means $\underline{W}$ a 4 x 1 vector of weights required, and $\underline{D}$ the 4 x 1 vector of mean differences between two groups on each of four variables. The solution for $\underline{W}$ is obtained by solving four simultaneous equations in four unknowns. The linear discriminant functions expressing the composite variable (A) in terms of a linear combination of four creativity measures optimally weighted for maximum separation between pairs of groups on A are given below:

1. Overachievers and Underachievers

$$A = 1x_1 + 52.36x_2 - 5.22x_3 + 13.51x_4 ,$$

2. Overachievers and Average achievers

$$A = 1x_1 + .447x_2 + 3.207x_3 - 4.571x_4 ,$$

3. Average achievers and Underachievers

$$A = -x_1 + 3.854x_2 + .540x_3 + 9.087x_4 ,$$

Variables x, x_2, x_3, and x_4 are measures of Fluency, Flexibility, Originality, and Elaboration respectively. Following the analysis outlined by Kendall (1948), after the weights for maximum discrimination were obtained 't'-tests were carried out to determine whether the differences between composite means were statistically significant.

Taking the three groups two at a time the differences were found to be significant at the .05 level of confidence.

These results support the second hypothesis. The three achievement groups did, in fact, perform differently on the creativity tests, to such an extent that these tests alone could be used to distinguish the three experimental groups. The overachievers did better than the average achievers who in turn did better than the underachievers. This finding was interpreted to mean that creativity is useful in school success.

Further Analysis of Reception Task Results

The two conclusions: (1) that overachievers were superior to average achievers, who in turn were superior to underachievers, in the efficiency with which they solved concept formation tasks; (2) that no difference existed among the concept formation tasks taken as a group led to a number of analyses designed to identify any possible related findings that might help to explain the relationship between achievement and concept formation.

A. Number of Attributes in the Concept Sought.

Both in reception and in selection tasks, the subject was required to isolate an equal number (three of each) of one-attribute, two-attributes, and three-attribute concepts.

An analysis was attempted to find what effect varying the number of attributes in the concept sought might have had on the subjects' performance on concept formation tasks. By considering each individual separately, irrespective of the achievement group to which he belonged, the problem of identifying the original achievement groups on the basis of performance as related to the number of attributes which was sought. For both reception and selection, by ranking the tasks according to the number of attributes (1, 2, 3) in the concept sought, and thereby ranking each subject's performance on these task categories (holding the subjects constant) the results of the two-way analysis of variance indicated that no significant differences existed among the subjects' performances on the tasks when a number of attributes was the criterion of distinction. From this analysis it was inferred that it was not possible to distinguish achievement groups on the basis of performance on problems of differing number of attributes. Following the same procedure with each of the three groups both on reception and selection yielded the same results. The analysis is summarized for reception and selection in Tables XXII and XXIII respectively. Varying the number of attributes did not differentially affect the subjects' performances either among or within achievement groups.

TABLE XXII

SUMMARY OF ANALYSIS OF VARIANCE: RECEPTION TASKS, ATTRIBUTES RANKED

A. TOTAL GROUP

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	84	125				
Among Attributes	.571	2	.286	.281	-.017	Not Significant
Among Subjects	0	41				
Among Attributes and Subjects	83.429	82	1.017			

B. OVERACHIEVERS

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	28	41				
Among Attributes	2.714	2	1.357	1.395	.027	Not Significant
Among Subjects	0	13				
Among Attributes and Subjects	25.286		.073			

TABLE XXII (continued)

C. AVERAGE ACHIEVERS

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	28	41				
Among Attributes	.143	3	.072	.067	-.071	Not Significant
Among Subjects	0	13				
Among Attributes and Subjects	27.857	26	1.071			

D. UNDERACHIEVERS

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	28	41				
Among Attributes	1.714	2	.857	.848	-.011	Not Significant
Among Subjects	0	13				
Among Attributes and Subjects	28.286	26	1.011			

TABLE XXIII

SUMMARY OF ANALYSIS OF VARIANCE: SELECTION TASKS, ATTRIBUTES RANKED

A. TOTAL GROUP

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	84	125				
Among Attributes	4.333	2	2.1666	2.23	.028	Not Significant
Among Subjects	0	41				
Among Attributes and Subjects	79.666	82	.972			

B. OVERACHIEVERS

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	28	41				
Among Attributes	2.70	2	1.35	1.387	.027	Not Significant
Among Subjects	0	13				
Among Attributes and Subjects	25.30	26	.973			

TABLE XXIII (continued)

C. AVERAGE ACHIEVERS

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	28	41				
Among Attributes	3	2	1.50	1.56	.039	Not Significant
Among Subjects	0	13				
Among Attributes and Subjects	25	26				

D. UNDERACHIEVERS

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	28	41				
Among Attributes	1.29	2	.645	.626	.03	Not Significant
Among Subjects	0	13				
Among Attributes and Subjects	26.71	26	1.03			

B. Set of Cards

As stated in Chapter IV, each set of cards was used to administer six tasks (three reception and three selection). Holding the subjects in the total group constant and ranking the tasks according to the set of cards used, the results of the two-way analysis of variance revealed differences significant at the .01 level both in reception and in selection tasks. In reception tasks, following the same procedure for each group no significant differences among sets were found for the average achievers and the overachievers but differences significant at the .05 level were found among the underachievers. In selection tasks no significant differences were found for the average achievers and the overachievers but differences significant at the .01 level were found among the underachievers. Clearly underachievers found some difficulty in changing from set to set while the other two groups more readily made the transition from one set of cards to another. The analysis for reception and selection tasks are summarized in Tables XXIV and XXV respectively.

C. Order of Task Presentation Within a Set

To ascertain the degree to which the subjects benefited from experience, the raw scores obtained on the first in each set were summed for each subject and compared with the sums similarly calculated for the second and the third

TABLE XXIV

SUMMARY OF ANALYSIS OF VARIANCE: RECEPTION TASKS, SETS OF CARDS RANKED

A. TOTAL GROUP

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	84	125				
Among Sets	9	2	4.50	4.918	.085	.01
Among Subjects	0	41				
Among sets and Subjects	75	82	.915			

B. OVERACHIEVERS

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	28	41				
Among Sets	1	2	.5	.482	-.039	Not Significant
Among Subjects	0	13				
Among sets and Subjects	27	26	1.038			

TABLE XXIV (continued)

C. AVERAGE ACHIEVERS

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	28	41				
Among Sets	3.857	2	1.929	1.923	.062	Not Significant
Among Subjects	0	13				
Among sets and Subjects	26.071	26	1.003			

D. UNDERACHIEVERS

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	28	41				
Among Sets	6.143	2	3.072	3.653	.159	.05
Among Subjects	0	13				
Among sets and Subjects	21.857	26	.841			

TABLE XXV

SUMMARY OF ANALYSIS OF VARIANCE: SELECTION TASKS, SETS OF CARDS RANKED

A. TOTAL GROUP

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	84	125				
Among Sets	13.905	2	6.953	8.132	.145	.01
Among Subjects	0	41				
Among Sets and Subjects	70.095	82	.855			

B. OVERACHIEVERS

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	28	41				
Among Sets	2.7	2	1.35	1.387	.027	Not Significant
Among Subjects	0	13				
Among Sets and Subjects	25.30	26	.973			

TABLE XXV (continued)

C. AVERAGE ACHIEVERS

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	28	41				
Among Sets	5.57	2	2.79	3.233	.138	Not Significant
Among Subjects	0	13				
Among Sets and Subjects	22.43	26	.863			

D. UNDERACHIEVERS

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	28	41				
Among Sets	9	2	4.50	6.156	.269	.01
Among Subjects	0	13				
Among Sets and Subjects	19	26	.731			

tasks in each set. Holding the subjects constant and ranking the sums according to the order of presentation differences significant at the .05 level were found in reception tasks but no differences were found in selection tasks. The same procedure used with each of the three groups on reception task results revealed no significant differences among the underachievers and the average achievers but order proved to be significant at the .05 level for the overachievers. On selection task results no significant differences were found for the overachievers and the average achievers but order proved to be significant at the .05 level for the underachievers. Examination of the ranked data clarifies this apparent contradiction. In reception tasks the overachievers consistently solved tasks one, two, and three in that order with increasing facility while in selection tasks the underachievers consistently solved tasks one, two, and three in that order with increasing difficulty as evident from Tables XV, XVI, and XVII. Clearly overachievers derive benefit from experience with similar tasks, while for underachievers experience with similar tasks has a deleterious effect. The results of the analysis regarding order of presentation of reception and selection tasks are given in Tables XXVI and XXVII respectively.

TABLE XXVI

SUMMARY OF ANALYSIS OF VARIANCE: RECEPTION TASKS, ORDER OF PRESENTATION RANKED

A. TOTAL GROUP

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	84	125				
Among Orders	6.33	2	3.1666	3.344	.052	.05
Among Subjects	0	41				
Among Orders and Subjects	77.666	82	.947			

B. OVERACHIEVERS

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	28	41				
Among Orders	7.000	2	3.5	4.332	.192	.05
Among Subjects	0	13				
Among Orders and Subjects	21	26	.808			

TABLE XXVI (continued)

C. AVERAGE ACHIEVERS

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	28	41				
Among Orders	1.857	2	.929	.923	-.006	Not Significant
Among Subjects	0	13				
Among Orders and Subjects	26.143	26	1.006			

D. UNDERACHIEVERS

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	28	41				
Among Orders	4	2	2	2.167	.077	Not Significant
Among Subjects	0	13				
Among Orders and Subjects	24	26	.923			

TABLE XXVII

SUMMARY OF ANALYSIS OF VARIANCE: SELECTION TASKS, ORDER OF PRESENTATION RANKED

A. TOTAL GROUP

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	84	125				
Among Orders	2.905	2	1.453	1.469	.011	Not Significant
Among Subjects	0	41				
Among Orders and Subjects	81.095	82	.989			

B. OVERACHIEVERS

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	28	41				
Among Orders	.14	2	.07	.065	-.072	Not Significant
Among Subjects	0	13				
Among Orders and Subjects	27.86	26	1.072			

TABLE XXVII (continued)

C. AVERAGE ACHIEVERS

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	28	41				
Among Orders	1	2	.50	.48	.029	Not Significant
Among Subjects	0	13				
Among Orders and Subjects	27	26	1.04			

D. UNDERACHIEVERS

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	28	41				
Among Orders	8.14	2	4.07	5.33	.236	.05
Among Subjects	0	13				
Among Orders and Subjects	19.86	26	.764			

D. Order of Presentation Across the Tasks

A more systematic way of investigating the effect of experience from one task to another was attempted. Both in reception and selection tasks, the group means on the nine tasks were subtotalled, taking the sum of tasks one, two, and three as the first subtotal; tasks two, three, and four as the second; tasks three, four, and five as the third; tasks four, five,and six as the fourth; tasks five, six, and seven as the fifth; tasks six, seven, and eight as the sixth and finally tasks seven, eight, and nine as the seventh subtotal. Holding the seven subtotals constant and ranking the three groups the analysis revealed highly significant differences among the groups both on reception and selection tasks. Holding the groups constant and ranking the seven subtotals significant differences at the .01 level were found on reception tasks, however, on selection tasks no significant differences were found. The fact that reception tasks were administered before selection tasks may account for the significant differences found on reception tasks and not on selection tasks. The results of these analyses, summarized in Table XXVIII, indicated that the achievement groups differed in the amount of benefit derived from previous experience with similar tasks: the overachievers gained most and the underachievers gained least.

TABLE XXVIII

SUMMARY OF ANALYSIS OF VARIANCE

A. RECEPTION TASKS: SEVEN SUBTOTALS RANKED

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	84	20				
Among Subtotals	63.333	6	10.556	6.130	.631	.01
Among Groups	0	2				
Among Subtotals and Groups	20.666	12	1.722			

B. RECEPTION TASKS: GROUPS RANKED

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Totals	14	20				
Among Groups	14	2	7.00	*	*	Beyond .01
Among Subtotals	0	6				
Among Subtotals and Groups	0	12	0			

* Note: The groups account for all of the variance.

TABLE XXVIII (continued)

C. SELECTION TASKS: SUBTOTALS RANKED

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	84	20				
Among Subtotals	45.333	6	9.056	2.81	.376	Not Significant
Among Groups	0	2				
Among Sub-totals and Groups	38.666	12	3.222			

D. SELECTION TASKS: GROUPS RANKED

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	14	20				
Among Groups	11.14	2	5.57	21.84	.748	Beyond .01
Among Subtotals	0	6				
Among Sub-totals and Groups	2.86	12	.255			

E. Number of Attributes Held in the Initial Response

By Bruner's (1956) definition a wholist (one who holds all the attributes given in the initial positive instance in his initial response) in this study is one who hold four attributes in his initial response. Subjects who hold fewer than four attributes are, therefore, partists. Assuming, however, that wholist and partist are the polar extremes on a single continuum, the it would seem reasonable to suggest that a subject who holds two attributes is not a partist to the same degree as one who holds a single attribute. Similarly a three-attribute response more closely approximates the wholist position than does a two-attribute response. Assuming a single continuum, the number of attributes held in the initial response were summed over groups on each task. Ranking the three group sums over the nine tasks the analysis revealed a significant difference among the groups at the .01 level on reception tasks but no differences on selection tasks, while ranking the tasks over the group sums yielded no significant differences among the tasks either in reception or in selection. These analyses, summarized in Table XXIX, indicated that on reception tasks the number of attributes held in the initial response varied significantly, the underachievers holding the least and the overachievers the most. This finding that overachievers are

TABLE XXIX

SUMMARY OF ANALYSIS OF VARIANCE

A. RECEPTION: NUMBER OF ATTRIBUTES RANKED

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	180	26				
Among Attributes	100.833	8	12.604	2.56	.342	Not Significant
Among Groups	0	2				
Among Attributes and Groups	78.833*	16	4.927			

* Corrections made for tied ranks.

B. RECEPTION: GROUPS RANKED

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	13	26				
Among Groups	0	8				
Among Attributes	14.888	2	7.444	37.98	.804	.01
Among Attributes and Groups	3.112	16	.196			

TABLE XXIX (continued)

C. SELECTION: NUMBER OF ATTRIBUTES RANKED

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	180	26				
Among Attributes	56.833	8	7.104	.996	-.001	Not Significant
Among Groups	0	2				
Among Attributes and Groups	114.167*	16	7.135			

* Correction made for tied ranks.

D. SELECTION: GROUPS RANKED

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	18	26				
Among Attributes	5.388	2	2.694	3.42	.212	Not Significant
Among Groups	0	8				
Among Attributes and Groups	12.612	16	.788			

more 'wholist' than underachievers on reception tasks but do not show the same difference on selection tasks can be interpreted to mean that reception tasks more closely appproximate procedures used by the subjects at school, while selection tasks more closely approximate procedures used by the subjects in the non-school environment. This interpretation seems reasonable since in reception tasks the examiner presents all the information and the subjects must use the information given in attempting to solve the task while in selection tasks the information is dependent on the subjects' choice and his attempts at solution must be made from the information so obtained. If reception tasks do, in fact, more closely approximate procedures used at school, than do selection tasks, the correlation between achievement and the number of attributes held in the initial response should be higher on reception tasks than on selection tasks. In this study these two variables correlate .36 on reception tasks and .04 on selection tasks which supports the argument presented. The intercorrelations for the thirty variables are given in Table XXX .

F. Number of Correct Solutions

Defining success on concept formation tasks as Bruner (1956) does according to the number of correct solutions no

TABLE XXX

INTERCORRELATIONS OF THIRTY VARIABLES*

TESTS	FLU.	FLEX.	ORIG.	ELAB.	R1	R2	R3	R4	R5	R6	R7	R8	R9	Rt	S1	S2	S3	S4	S5	S6	S7	S8	S9	St	SCAT	ACH.	Sh	Sc	Rh	Rc
FLU.	1.00	819	917	943	230	341	276	419	362	476	422	498	219	291	240	054	224	037	280	394	511	072	-059	156	111	425	174	098	320	-001
FLEX.		1.00	832	806	377	440	363	522	396	523	450	445	220	376	208	068	201	-015	227	547	429	-000	-094	183	315	568	124	292	377	264
ORIG.			1.00	941	266	288	302	474	364	464	397	515	179	280	187	034	236	020	275	435	485	033	-082	157	158	475	162	124	292	-006
ELAB.				1.00	234	311	251	385	348	506	435	525	190	253	235	039	279	049	231	413	511	075	-051	138	145	450	125	113	288	-046
R1					1.00	595	673	673	666	488	603	460	516	779	188	086	411	223	306	327	269	091	-120	384	181	477	237	288	660	469
R2						1.00	678	640	499	658	544	605	449	576	171	215	534	243	291	522	467	090	120	317	269	621	213	366	556	467
R3							1.00	918	491	560	361	610	352	612	-095	068	430	215	335	410	378	-045	-238	297	102	625	224	206	418	349
R4								1.00	490	538	387	611	399	626	-115	007	323	150	433	480	405	-059	-258	287	216	681	191	284	405	356
R5									1.00	610	765	606	637	808	350	282	495	225	437	252	307	338	197	530	270	414	412	312	857	370
R6										1.00	543	851	558	572	387	260	632	143	198	443	546	210	016	341	295	656	279	245	662	356
R7											1.00	610	704	780	412	264	400	147	387	244	442	300	142	476	327	427	414	253	815	503
R8												1.00	570	586	371	310	719	279	281	315	686	226	042	449	177	603	412	229	608	411
R9													1.00	815	340	317	318	228	444	157	285	350	179	595	316	306	387	437	727	548
Rt														1.00	344	348	344	246	443	151	234	204	162	608	353	420	413	492	844	581
S1															1.00	750	368	314	180	105	367	416	426	680	119	022	624	204	391	323
S2																1.00	385	354	109	-019	138	418	377	743	152	-066	733	268	354	328
S3																	1.00	342	052	307	489	212	116	431	038	417	427	039	501	254
S4																		1.00	407	224	361	294	386	619	094	120	477	331	140	251
S5																			1.00	429	426	392	156	549	138	269	488	180	350	150
S6																				1.00	591	087	-051	232	266	598	156	165	135	150
S7																					1.00	149	-022	368	022	504	370	092	269	239
S8																						1.00	303	596	019	001	611	111	273	210
S9																							1.00	485	115	-163	241	236	141	035
St																								1.00	160	159	816	403	496	469
SCAT																									1.00	619	-005	547	293	402
ACH.																										1.00	044	297	359	358
Sh																											1.00	048	468	293
Sc																												1.00	222	531
Rh																													1.00	393
Rc																														1.00

NOTE: *decimal point omitted

significant differences were found among the groups on either reception or selection tasks. The summary of these analyses is given in Table XXXI. However, using the proposed efficiency measure, the groups were found to differ both on reception tasks (Table XIV) and on selection tasks (Table XVIII). Clearly so gross a measure of success and failure as correct-incorrect conceals differences :(1) between completely implausible responses and responses that closely approximate the correct solution; and (2) the efficiency with which available information is utilized. It would appear that the efficiency measure proposed in this study quantifies both of the above differences and provides a better estimate of success than that provided by the number of correct solutions. On selection tasks the efficiency measure correlates .40 (Table XXX) with the correct-incorrect measure which indicates that the two measures account for only sixteen per cent of the common variance. On reception tasks the correlation of .58 indicates that thirty-five per cent of the variance is accounted for by both measures. The correlation between efficiency and achievement on selection tasks is .16 while the correlation between number of correct solutions and achievement is .30. The correlation between efficiency and achievement on reception tasks is.42 while

TABLE XXXI

SUMMARY OF ANALYSIS OF VARIANCE

A. RECEPTION: NUMBER OF CORRECT RESPONSES RANKED

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	180	26				
Among Responses	117.667	8	14.708	4.37	.53	.05
Among Groups	0	2				
Among Responses and Groups	53.833*	16	3.365			

* Correction made for tied ranks

B. RECEPTION: GROUPS RANKED

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	18	26				
Among Groups	3.17	2	1.59	1.71	.073	Not Significant
Among Responses	0	8				
Among Groups and Responses	14.83	16	.93			

TABLE XXXI (continued)

C. SELECTION: NUMBER OF CORRECT RESPONSES RANKED

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	180	26				
Among Responses	111.833	8	13.979	3.60	.46	.05
Among Groups	0	2				
Among Responses and Groups	62.167*	16	3.885			

* Correction made for tied ranks.

D. SELECTION: GROUPS RANKED

Source of Variation	S.S.	df	M.S.	F_r	R_r	Level of Significance
Total	18	26				
Among Groups	2.388	2	1.194	1.23	.025	Not Significant
Among Responses	0	8				
Among Groups and Responses	15.612	16	.975			

correlations are higher than the .30 and .36 correlations found between number of correct solutions and achievement. The correct-incorrect dichotomy, although presumably a measure of problem solving success, is measuring more in common with intelligence than with achievement. The correlations between the efficiency measure and intelligence are .35 and .16 for reception and selection tasks respectively. As noted above the correlations between efficiency scores and achievement are .42 and .16 for reception and selection respectively. Clearly the efficiency measure has more in common with achievement than with intelligence, is more closely related to achievement, and not so closely related to intelligence as is the Bruner correct-incorrect measure.

A Factor Analytic Approach to the Data

Some of the intercorrelations (Table XXX) have been mentioned in the discussion related to the number of attributes held in the initial response and the number of correct solutions. Upon further examination of the table of intercorrelations a number of additional observations become evident.

Of the six correlations among indices of creativity, three are greater than .8 and three are greater than .9.

the correlation between the number of correct solutions and achievement is .36. If, as has been pointed out earlier, reception tasks more closely approximate school procedures than do selection tasks, then school success (achievement) should be more closely related to success on reception tasks than on selection tasks. The correlations between achievement and number of correct solutions (.30 and .36) do not account for this difference, while the correlations between achievement and the efficiency measure (.16 and .42) more clearly distinguish between the two types of tasks.

Holding the groups constant and ranking the tasks according to the number of correct solutions significant differences at the .05 level were found both on reception and on selection tasks. The analyses are summarized in Table XXX. This finding might be interpreted to mean that the tasks differed but earlier analyses have shown that the tasks do not differ. The fact that, as tasks are presented a larger number of subjects successfully identify the concept sought, is more reasonably interpreted to mean that subjects learn from previously administered tasks. The correlations between the number of correct responses and SCAT are .40 and .55 for reception and selection tasks respectively. Both of these

These correlations indicate that the four indices are measuring a common factor. Moreover, this common factor appeared to be more closely associated with achievement than with intelligence since the correlations of each of the four indices with achievement is in the order of .5 and with SCAT is in the order of .1.

The correlations between the proposed efficiency measure and the number of attributes held in the initial response were .844 and .816 for reception and selection tasks respectively. However, neither of the two measures correlated better than .3 with the indices of creativity suggesting the existence of a second factor.

In an attempt to reduce the mass of data contained in the table of intercorrelations, factor analysis was used here as one way of examining all the data. In all 30 variables were included in the analysis: 4 creativity measures-fluency (flu.); flexibility (flex.); originality (orig.); and elaboration (elab); 20 efficiency measures 9 from reception tasks (R 1, 2, . . . 9) 9 from selection tasks (S 1,2 . . .9) and the totals for each group on these tasks (R_t and S_t); a measure of intelligence (SCAT); a measure of achievement (Ach); the number of attributes held by the subject in the initial responses on reception tasks (R_h); the number of attributes held by the subject

in the initial response on selection tasks (S_h); the number of correct solutions on reception tasks(R_c); the number of correct solutions on selection tasks (S_c). The five factors extracted are given in Table XXXII.

The method of principal components which maximizes the variance accounted for by each factor taken out, was used in factoring the correlation matrix. The procedure used, based upon an eigenvalue-eigenvector solution, permitted 30 factors to be found. Of these five were selected as being psychologically meaningful. These five factors accounted for 73.27 per cent of the total variance. A graphical transformation employing the principle of Thurstone's "simple structure" (1940) was applied to the five factors and the factors interpreted psychologically. Table XXXIII contains the transformed factors, while Table XXXIV the transformation matrix used in transforming the principal component factors to their final and intuitively most meaningful position. The results of this analysis indicated that achievement and creativity are heavily loaded on factor one; that success on reception tasks is more closely related both to creativity and to achievement than is success on selection tasks; and that intelligence as presently measured bears little relationship to any of

the other variables except the number of correct solutions on selection tasks.

The efficiency measure includes more of factor two than does the wholist-partist measure on selection tasks. The number of correct solutions is much more heavily loaded on factor four than is the efficiency measure.

On reception tasks both the number of attributes held in the initial response and the number of correct solutions have some loadings on factor four, however, the efficiency measure has a loading of .006 on this factor. Factor three is loaded most heavily on fluency, originality, and elaboration but not as heavily loaded on flexibility.

The five factors, in order, are perhaps best described by the following terms: (1) divergent thinking; (2) convergent thinking; (3) productivity; (4) intelligence; and (5) error.

TABLE XXXII

PRINCIPAL DOMPONENT FACTOR LOADINGS OF 30 VARIABLES*

Variable	Factor I	Factor II	Factor III	Factor IV	Factor V	h^2
Flu.	575	-477	540	-213	-089	903
Flex.	633	-498	287	-320	073	839
Orig.	575	-518	508	-209	-047	903
Elab.	568	-496	558	-221	-077	935
R_1	704	-082	-408	103	-161	705
R_2	741	-148	-239	151	115	664
R_3	663	-305	-379	419	030	853
R_4	701	-412	-308	250	102	829
R_5	796	123	-141	-100	-293	764
R_6	803	-162	008	057	-145	695
R_7	789	090	-072	-220	-293	770
R_8	830	-090	072	197	-151	764
R_9	714	277	-254	-188	-151	709
RT	826	172	-371	-177	-192	918
S_1	476	543	425	-149	-056	727
S_2	412	656	239	-032	008	658
S_3	612	092	085	406	-171	584
S_4	381	418	112	292	475	643
S_5	524	129	098	151	269	396
S_6	517	352	156	204	471	679
S_7	626	-176	356	342	179	699
S_8	337	539	272	043	005	480
S_9	133	580	215	-225	187	486
S_T	673	627	148	077	172	903
SCAT	378	-043	-274	-560	414	705

* Note: Decimal point omitted

TABLE XXXII (continued)*

Variable	Factor I	Factor II	Factor III	Factor IV	Factor V	h^2
Ach.	670	-463	-180	005	285	777
S_h	544	568	313	261	-038	786
S_c	432	156	-287	-456	479	731
R_h	782	174	-184	-139	-439	888
R_c	551	246	-412	-151	180	589

* Decimal point omitted.

Total Sum of Squares	11.565	4.199	2.690	1.824	1.704	21.982

TABLE XXXIII

ROTATED FACTORS BASED ON 30 VARIABLES USED IN THE STUDY*

Variable	Factor I'	Factor II'	Factor III	Factor IV'	Factor V'	h^2
Flu.	747	002	540	219	074	903
Flex.	805	023	287	288	-157	839
Orig.	773	-030	508	126	-1	902
Elab.	754	017	558	115	-204	935
R_1	593	388	-408	184	-053	705
R_2	664	361	-239	-037	186	664
R_3	704	190	-379	-294	299	851
R_4	802	132	-308	-120	242	828
R_5	533	604	-141	-119	-286	765
R_6	720	390	008	-139	-071	695
R_7	548	574	-072	-029	-365	769
R_8	695	462	072	-248	017	763
R_9	371	670	-254	041	-238	709
RT	524	661	-370	006	-261	917
S_1	018	722	425	075	-140	727
S_2	-103	767	239	029	-015	657
S_3	411	462	085	-418	140	584
S_4	025	565	112	095	549	643
S_5	320	434	098	065	302	396
S_6	622	061	156	158	488	678

* Note: Decimal point omitted.

TABLE XXXIII (continued)*

Variable	Factor I'	Factor II'	Factor III	Factor IV'	Factor V'	h^2
S_7	593	265	356	-138	360	697
S_8	-086	630	272	-029	032	480
S_9	-269	531	215	292	-008	486
S_T	116	912	148	056	180	903
SCAT	318	209	-274	694	-060	705
Ach.	811	073	-180	185	217	777
S_h	054	784	313	221	144	785
S_c	232	396	-287	659	058	731
R_h	489	634	-184	186	-421	887
R_c	266	542	-412	232	035	589
Total Sums of Squares	8.541	7.213	2.689	1.809	1.719	21.971

* Decimal point omitted.

TABLE XXXIV

TRANSFORMATION MATRIX

	I'	II'	III'	IV'	V'
I	.768	-.640	0	0	0
II	.640	.768	0	0	0
III	0	0	1	0	0
IV	0	0	0	.750	.661
V	0	0	0	-.661	.750

CHAPTER VI

SUMMARY AND CONCLUSIONS

Educators, at the beginning of this century, expected the intelligence test to provide the long-sought explanation of individual differences in academic achievement. Although significant relationships between measured intelligence and achievement were found to exist, the discrapancies suggested that achievement was related to factors other than measured intelligence. In spite of the extensiveness of this search for related factors, which is briefly reviewed in Chapter II, the problem clearly requires additional research.

Summary of the Study

This study is an attempt to apply cognitive theory to explain inter-individual differences in achievement. Since both achievement and intelligence purport to measure cognitive functioning the correlations between the scores obtained on these two measures is a function of the degree to which either or both of the measuring instruments sample the cognitive process. The literature suggests that concept formation tasks, creativity tests and achievement tests gauge some aspects of cognition not now measured by intelligence tests. This investigation was carried out on the

assumption that either concept formation tasks or creativity tests or both measure a factor which influences scholastic achievement. The scores of overachievers, average achievers, and underachievers on a battery of concept formation tasks and creativity tests were analyzed. Subject to the limitations imposed by the small sample, a number of conclusions were drawn.

Conclusions

In an attempt for greater clarity the conclusions of the study are discussed in three sections:

1. Concept formation and achievement.
2. Creativity and achievement.
3. General conclusions.

Concept Formation and Achievement

Efficiency as a Criterion of Success.

When efficiency as measured here, (page 70) is the criterion of success on concept formation tasks, subjects grouped on the basis of achievement succeed in direct relationship to their level of achievement both on reception and on selection tasks. These would seem to be true differences, in that the [illegible] [illegible] differences among reception tasks, and that only one selection task differed from the remaining eight, all three groups having found it more difficult. The differences found

among groups could not therefore be attributed to differences in tasks. In view of the fact that this experiment was designed so that the groups were equated on the intelligence variable and varied on the achievement dimension, this suggests that the efficiency with which students form concepts accounts for some of the variation in achievement which is no predicted by intelligence tests.

Number of Correct Responses as the Criterion of Success

Bruner (1956) defines success on concept formation tasks in terms of the number of correct responses. Applying this criterion of success, no significant differences were found among the groups. As explained in Chapter V. (page 125), this gross measure of success conceals differences between implausible responses and thos closely approximating the correct solution and differences in the efficiency with which available information is utilized. The efficiency measure developed in this study accords credit for partial solutions and immediate use of available information and is therefore a more sensitive measure of success than that based on the number of correct responses.

When groups were held constant and tasks ranked according to the number of correct solutions, significant differences were found among both reception and selection tasks. The fact that the number of correct solutions is directly related to the position of the task in the sequence

was interpreted to mean that subjects learn from previously administered tasks. The evidence suggests that the number of correct solutions is a function of intelligence, the correlations between intelligence and performance on reception and selection tasks being respectively .40 and .55. This conclusion is also supported by the fact that both on reception and selection tasks significant differences were found for each group in the number of correct solutions, when in each group the five subjects with the highest intelligence scores were compared with the five subjects with the lowest intelligence scores. The inevitable conclusion (certainly not new) is that intelligence bears a high relationship to the number of concept formation tasks correctly solved.

The Wholist and Partist Approaches to Problem Solving

Bruner (1956) dichotomizes subjects on concept formation tasks as wholists (those who hold all the attributes of the initial positive instance in their first response) and partists (those who do not use this procedure). On the basis of this dichotomy, few of the subjects in this study would be classified as wholists. These few were very nearly equally distributed over the three groups and failed to produce any significant differences between groups. Bruner's assumption that subjects can be classified as either wholists

or partists suggests two distinct problem-solving strategies and makes no differentiation among partists, some of whom hold more attributes than others. The number of attributes held in the initial response were summed over the nine tasks for each subject and the sums were analyzed to ascertain any differences among the groups. The overachievers held more attributes than the average achievers who in turn held more than the underachievers. By Bruner's definition this result would be interpreted to mean that the overachievers employ the partist strategy more successfully. However, on the assumption that there is but one problem solving strategy which is more or less efficiently employed, the result can be interpreted to mean that overachievers as a group are better problem solvers than are either the average achievers or the underachievers. Given either of the above interpretations, school success (academic achievement) is in part a function of the degree to which an individual has developed his problem solving skills, in effect, the efficiency with which he isolates concepts.

Other Considerations

Although no over all differences were found among tasks, consideration was given to the possibility that performance might be affected by the number of attributes in the concept sought, by the set of cards used, by the order

of presentation within a set, and by the order of presentation across sets.

The Number of Attributes in the Concept Sought

There were three one-attribute, three two-attribute, and three three-attribute tasks in both the reception and the selection groupings of tasks. No significant differences were found among achievement groups or within achievement groups, either in reception or in selection tasks, when the number of attributes in the concept was treated as the variable. Varying the number of attributes from one to three did not permit discrimination among the groups but this may have been because all of these attributes were easily perceived and easily retained. Increasing the number of attributes to four or more (seven is considered maximum) might have changed this result.

Set of Cards Used

Each set of cards was used for three tasks. Treating sets as the variable, underachievers as a group were found to differ from the other two groups. It appears that underachievers find it more difficult to change from one type of symbol input of information to another. This suggests that underachievers may learn more slowly or that underachievers are less flexible or that underachievers adapt less readily.

The present evidence is, however, insufficient to warrant any one specific conclusion, but if the suggestions are nothing more than different ways of phrasing the same idea, the results (to be discussed later) on the creativity test where underachievers proved to be less flexible than the other groups corroborated the results obtained when sets were treated as the variable.

Order of Presentation Within a Set

To test the effect of 'order of presentation within a set' three subtotals were calculated: tasks 1, 4, and 7; tasks 2, 5, and 8; and tasks 3, 6, and 9. The results of this analysis showed that overachievers differed from the two other groups on reception tasks while underachievers differed from the other two groups on selection tasks. Examination of the ranked data clarifies this apparent contradiction. In reception the overachievers consistently solved task 1, 2, and 3 in that order with increasing facility. This might be interpreted to mean that overachievers profited from experience or that overachievers are more flexible. Given the above interpretations as tenable , in selection the underachievers did not profit from experience. In fact, experience seemed to have an inhibiting effect, or underachievers are less flexible.

Order of Presentation Across Tasks

A more systematic way of investigating the effect of experience from one task to another was attempted. Seven sub-totals of three tasks were calculated for each achievement group. The sum of the means of tasks 1, 2, and 3 was the first sub-total. By deleting the first task and adding the fourth a second sub-total was found. This process was repeated until all tasks had been included, the last sub-total made up of the means of tasks 7, 8, and 9. On reception tasks significant differences were found among the sums when achievement groups were held constant, but no differences were found on selection tasks. Clearly the groups differed in the rapidity with which they 'learned' to solve the concept formation tasks. This difference was apparent on reception tasks but not on selection tasks probably because reception tasks were administered before selection tasks and all groups had reached their maximum by the time nine tasks had been administered. The analysis of the seven subtotals on reception tasks revealed the fact that two of the groups: average achievers and overachievers reached a plateau by the time seven tasks had been presented and further, that the overachievers had very nearly reached their peak after four tasks had been presented. The implication that overachievers learn more quickly than average

achievers who in turn learn more quickly than underachievers was checked holding the seven subtotals constant and comparing the groups. Ranked in this way fourteen firsts, fourteen seconds, and fourteen thirds are possible. Overachievers placed first fourteen times; average achievers came second twelve times; and underachievers came third twelve times. As expected analysis of these rankings indicated a highly significant difference interpreted here to mean that overachievers learned most quickly and underachievers learned least quickly and further that underachievers failed to close the gap between their results and those of the other groups over the eighteen tasks.

Creativity and Achievement

Analysis of the creativity test results of the three groups taken in pairs revealed a significant relationship between creativity and level of achievement. If creativity tests do in fact measure creativity, then the more creative individuals are more successful at school when scores on achievement tests are used to guage success. An attempt was made to determine what weights assigned to each of the four indices of creativity would best discriminate between pairs of achievement groups.

In discriminating between overachievers and underachievers the weights that provided maximum separation were

approximately 1, 52, -5, and 14 on Fluency, Flexibility, Originality, and Elaboration respectively. Although Elaboration received thirteen times as much weight as Fluency, by far the greatest weight was assigned to the Flexibility index. This result supported the earlier finding (page 111) that underachievers found it more difficult to adjust to new sets of symbols than did the other two groups.

In discriminating between overachievers and average achievers the weight that provided maximum separation were approximately 2, 1, 7, and 9 on Fluency, Flexibility, Originality, and Elaboration respectively. Although the best indices of discrimination between these two groups were Originality and Elaboration, each of the four indices received a more equitable share of the weights than was the case in the separation between overachievers and underachievers.

In discriminating between average achievers and underachievers the weights were approximately 2, 8, 1, and 18 for Fluency, Flexibility, Originality, and Elaboration respectively. The most effective indices of discrimination were Flexibility and Elaboration.

Clearly, lack of flexibility is a mark of the underachiever and the other indices of creativity are sufficiently important in discriminating between groups to warrant the

conclusion that creativity is directly related to achievement.

General Conclusions

The factor analytic approach, used to here reduce the mass of data contained in the intercorrelation table, isolated five psychologically meaningful factors. The five factors, in order, are perhaps best described by the following terms: (1) divergent thinking; (2) convergent thinking; (3) productivity; (4) intelligence; and (5) error.

On factor 1, loadings in the order of .8 on Flexibility and achievement, and in the order of .7 on the other three creativity indices, suggest a high degree of relationship between achievement and creativity. Since selection task loadings on this factor are in the order of .1 and reception task loadings are in the order of .5 it would appear that for this sample 'divergent thinking' is useful in the solution of reception tasks but of very little importance in selection tasks.

'Congergent thinking' seems to describe the second factor since the four creativity indices had zero loadings on this factor. The highest loading on factor two was .912 on selection task total. Loadings of .784 and .634 on the number of attributes held in the initial response on selec-

tion and reception tasks respectively suggest that convergent thinking is important in the solution of concept formation tasks. Further examination of factor 2 loadings on the separate tasks suggests that divergent thinking is increasingly important as the subject progresses from one reception task to another while in selection it becomes less important from task to task.

Productivity is perhaps a suitable way of defining the third factor with loadings in the order of .5 on Fluency, Originality, and Elaboration and less than .3 on Flexibility. The scores on the creativity indices except for Flexibility, are largely determined by the number of responses, without regard for the adequacy of these responses. The negative loadings on intelligence, achievement, on number of correct responses in selection tasks, and on number of correct responses in reception tasks seem to suggest that factor 3 is appropriately named.

Factor 4 is 'intelligence' with the highest loading .694 on SCAT. The only other variable loaded above .2 is the number of correct solutions on selection tasks with a loading of .659. The loading below .2 would appear reasonable since the groups were equated on intelligence and since the intelligence scores for the sample were within a narrow range. The high loading on correct solutions on

selection tasks supports the assumption that solving selection tasks more closely approximates the acquisition of information from the non-school environment.

Briefly, the findings of this study may be reported as follows:

1. On the basis of the Lambert Measure of Problem-Solving Efficiency, overachievers are more efficient than are underachievers.

2. On the basis of the creativity instruments here employed, overachievers are more creative than underachievers.

3. On the basis of the Flexibility index used, overachievers are more flexible than underachievers.

These three findings taken together lead to the conclusion that creativity tests and concept formation tasks measure some aspect of behavior that is not now measured by intelligence tests but of which school success is a function.

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APPENDICES

APPENDIX A

TESTING INSTRUMENTS

A. Concept Formation Tasks

1. Materials used in Concept Attainment Tasks.

Three sets of 81 different 3 x 4 cards were used in this experiment. The 81 cards represented all the possible ways of combining 4 attributes each of which can take 3 values. The symbols varied from set to set but the number of attributes and attribute values remained constant. In set one the color attribute values were red (R), black (Bk), and green (Gr); the figure attribute values were square (□), circle (O), and triangle (Δ); the capital letter attribute values were capital A (A), capital B (B), and capital C (C); and the small letter attribute values were small a (a), small b (b), and small c (c). The attributes appeared on the cards in set one in code form.

In set two a bird was printed inside a frame on each card. The size attribute values were small (s), medium (M), and large (L); the color attribute values were blue (Bl), yellow (Y), and red (R); the position attribute values were flying (Fly), standing (St), and perching (Per); the frame attribute values were open side border (OS), open corner border (OC), and closed border (Cl). The birds were printed on the cards.

In set three a young man's face was printed on each card. The color of hair attribute values were fair hair (F.H.), black hair (Bk.H), and brown hair (Br.H); the color of tie attribute values were blue tie (BeT), black tie (BkT), and red tie (RT); the view of head attribute values were the view of head attribute values were view of left side of the face (Left), view of right side of the face (Right), and front view of the face (Front); and the eye attribute values were right eye open (RO), left eye open (LO), and both eyes open (BO). The faces were printed on the cards.

SYMBOLS ON SET ONE OF THE CARDS

Bk.□Aa	Bk.△Aa	Bk.○Aa	R□Aa	R△Aa	R○Aa	Gr.□Aa	Gr.△Aa	Gr.○ Aa
Bk.□Ab	Bk.△Ab	Bk.○Ab	R□Ab	R△Ab	R○Ab	Gr.□Ab	Gr.△Ab	Gr.○ Ab
Bk.□Ac	Bk.△Ac	Bk.○Ac	R□Ac	R△Ac	R○Ac	Gr.□Ac	Gr.△Ac	Gr.○Ac
Bk.□Ba	Bk.△Ba	Bk.○Ba	R□Ba	R△Ba	R○Ba	Gr.□Ba	Gr.△Ba	Gr.○Ba
Bk.□Bb	Bk.△Bb	Bk.○Bb	R□Bb	R△Bb	R○Bb	Gr.□Bb	Gr.△Bb	Gr.○Bb
Bk.□Bc	Bk.△Bc	Bk.○Bc	R□Bc	R△Bc	R○Bc	Gr.□Bc	Gr.△Bc	Gr ○Bc
Bk.□Ca	Bk.△Ca	Bk.○Ca	R□Ca	R△Ca	R○Ca	Gr.□Ca	Gr.△Ca	Gr.○Ca
Bk.□Cb	Bk.△Cb	Bk.○Cb	R□Cb	R△Cb	R○Cb	Gr.□Cb	Gr.△Cb	Gr.○Cb
Bk.□Cc	Bk.△CC	Bk.○Cc	R□Cc	R△Cc	R○Cc	Gr.□Cc	Gr.△Cc	Gr.○Cc

SYMBOLS ON SET TWO OF THE CARDS

S Be FlyCl	S Y FlyCl	S R FlyCl	M Be FlyCl	M Y FlyCl	M R FlyCl	L Be FlyCl	L Y FlyCl	L R FlyCl
S Be FlyOS	S Y FlyOS	S R FlyOS	M Be FlyOS	M Y FlyOS	M R FlyOS	L Be FlyOS	L Y FlyOS	L R FlyOS
S Be FlyOC	S Y FlyOC	S R FlyOC	M Be FlyOC	M Y FlyOC	M R FlyOC	L Be FlyOC	L Y FlyOC	L R FlyOC
S Be Per Cl	S Y Per Cl	S R Per Cl	M Be Per Cl	M Y Per Cl	M R Per Cl	L Be Per Cl	L Y Per Cl	L R Per Cl
S Be Per OS	S Y Per OS	S R Per OS	M Be Per OS	M Y PerOS	M R Per OS	L Be Per OS	L Y Per OS	L R Per OS
S Be Per OC	S Y Per OC	S R Per OC	M Be Per OC	M Y Per OC	M R Per OC	L Be Per OC	L Y Per OC	L R Per OC
S Be St Cl	S Y St Cl	S R St Cl	M Be St Cl	M Y St Cl	M R St Cl	L Be St Cl	L Y St Cl	L R St Cl
S Be St OS	S Y St OS	S R St OS	M Be St OS	M Y St OS	M R St OS	L Be St OS	L Y St OS	L R St OS
S Be St OC	S Y St OC	S R St OC	M Be St OC	M Y St OC	M R St OC	L Be St OC	L Y St OC	L R St OC

SYMBOLS ON SET THREE OF THE CARDS

BrH RT Full LO	BrH BeT Full LO	BrH BkT Full LO	FH RT Full LO	FH BET Full LO	FH BkT Full LO	BkH RT Full LO	BkH BeT Full LO	BkH BkT Full LO
BrH RT Full RO	BrH BeT Full RO	BrH BkT Full RO	FH RT Full RO	FH BET Full RO	FH BkT Full RO	BkH RT Full RO	BkH BeT Full RO	BkH BkT Full RO
BrH RT Full BO	BrH BeT Full BO	BrH BkT Full BO	FH RT Full BO	FH BET Full BO	FH BkT Full BO	BkH RT Full BO	BkH BeT Full BO	BkH BkT Full BO
BrH RT Left LO	BrH BeT Left LO	BrH BkT Left LO	FH RT Left LO	FH BET Left LO	FH BkT Left LO	BkH RT Left LO	BkH BeT Left LO	BkH BkT Left LO
BrH RT Left RO	BrH BeT Left RO	BrH BkT Left RO	FH RT Left RO	FH BET Left RO	FH BkT Left RO	BkH RT Left RO	BkH BeT Left RO	BkH BkT Left RO
BrH RT Left BO	BrH BeT Left BO	BrH BkT Left BO	FH RT Left BO	FH BET Left BO	FH BkT Left BO	BkH RT Left BO	BkH BeT Left BO	BkH BkT Left BO
BrH RT Rt. LO	BrH BeT Rt. LO	BrH BkT Rt. LO	FH RT Rt. LO	FH BET Rt. LO	FH BkT Rt. LO	BkH RT Rt. LO	BkH BeT Rt. LO	BkH BkT Rt. LO
BrH RT Rt. RO	BrH BeT Rt. RO	BrH BkT Rt. RO	FH RT Rt. RO	FH BET Rt. RO	FH BkT Rt. RO	BkH RT Rt. RO	BkH BeT Rt. RO	BkH BkT Rt. RO
BrH RT Rt. BO	BrH BeT Rt. BO	BrH BkT Rt. BO	FH RT Rt. BO	FH BET Rt. BO	FH BkT Rt. BO	BkH RT Rt. BO	BkH BeT Rt. BO	BkH BkT Rt. BO

Code Sheets

Three code sheets were prepared, one for each set of cards, to facilitate the subjects' hypotheses writing. Code sheets also served to clearly focus the subjects' attention on the attributes and their values. The code sheets are reproduced here in the form in which they were used in the testing.

ATTRIBUTES AND EQUIVALENT ABBREVIATIONS

Code Sheet I

The following abbreviations may be used in the attempts at solution of Problems I, II, and III.

Color		Figure	
Red	R	Triangle	△
Black	Bk	Square	□
Green . . .	Gr	Circle	○

Capital Letters		Small Letters	
Capital A . . .	A	Small a	a
Capital B . . .	B	Small b	b
Capital C . . .	C	Small c	c

ATTRIBUTES AND EQUIVALENT ABBREVIATIONS

Code Sheet II

The following abbreviations may be used in the solutions of Problems IV, V, and VI.

Color	Size
Yellow . . . . . Y	Large L
Red . . . . R	Medium . . . . . M
Blue . . . . Be	Small . . . . S

Position	Border
Flying . . . . . Fly	Open on Side . . . OS
Standing . . . . St.	Open on Corner . . OC
Perching . . . . Per.	Closed Cl

ATTRIBUTES AND EQUIVALENT ABBREVIATIONS

Code Sheet III

The following abbreviations may be used in the solution of Problems VII, VIII, and IX.

Color of Hair	Color of Tie
Fair Hair . . . . F.H.	Blue Tie . . . . . Be.T
Black Hair . . . Bk.H.	Black Tie . . . . Bk.T
Brown Hair . . . Br.H.	Red Tie . . . . . RT
View of Head	**Eyes**
. . . . Left	Right eye Open . . . R.O.
. . . . Front	Left eye Open . . . L.O.
. . . . Right	Both eyes Open . . . B.O.

Response Sheets

Completing the materials used were two answer sheets which are reproduced below. Responses to Selection Tasks were given one Sheet One. For Reception Tasks, Sheet Two was used.

Sheet One

ANSWER SHEET

Subject's Name ____________________ Problem No. ____

	Card Chosen	Pos. or Neg.	Time	Concepts Verbalized by Subject
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

Sheet Two

ANSWER SHEET

Number: ____________________

Subject' Name

Problem Number

1.
2.
3.
4.
5.
6.

B. Creativity Tests

1. Materials Used in Creativity Tests

a. Cover Sheet

NAME: ______________________ DATE: ____________________

AGE: ______________ GRADE: _______ SCHOOL: ____________

TEACHER: ________________ FATHER'S OCCUPATION __________

WHAT OCCUPATION DO YOU WANT TO ENTER WHEN YOU GROW UP? ____

____

INSTRUCTIONS: This booklet contains several tasks which will require you to use your imagination. There are no "correct" or "incorrect" answers in the usual sense. There are many possible answers or solutions to each problem. In most cases, you will be asked to think of as many possible solutions as you can. Do not be afraid to guess or to put down the ideas which you think up. You are urged to think of solutions which have never been thought of before.

You will be timed on each task. Work as rapidly as you can without hurrying.

Do not open this booklet until given instructions to do so.

TO BE FILLED IN BY JUDGES

Fluency ______________

Flexibility ___________

Originality ___________

Elaboration ___________

Grand Total ___________

b. Task 1.

List below the cleverest, most interesting, and most unusual ways you can think of for changing the toy dog you will be shown so that children would have more fun playing with it.

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c. Task II.

List below the cleverest, most interesting, and most unusual uses you can think of for this toy dog other than as a plaything.

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d. Task III. DIVERGENT QUESTION TEST (Burkhart):

In this task you will first be given the name of an object. You are to think of as many questions as you can about the object. These questions should lead to a variety of different answers which might arouse curiosity and interest in others concerning this object. Try to think of questions about aspects of the object which people do not usually think about.

OBJECT: TIN CAN (5 min.)

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e. Task IV. UNUSUAL USES

You will be given the name of an object and your task will be to think of as many interesting, unusual, and exciting uses as you can of the object. There is no limit to the quantity and quality of the object at your disposal.

OBJECT: TIN CANS

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f. Task V. CIRCLES

In ten minutes see how many objects you can make from the circles below. A circle should be the main part of whatever you make. With pencil or crayon add lines to the circles to complete your picture. Your lines can be inside the circle, outside the circle, or both inside and outside the circle. Try to think of things that no one else in the class will think of. Make as many things as you can and put as many ideas as you can in each one

Add names or titles if it is hard to tell what the object is.

36 CIRCLES WITH DIAMETER OF ONE INCH

g. Task VI. ASK AND GUESS

The next three tasks will be based on a picture (Little Boy Blue Scene) which will be displayed at the front of the room. The first task will give you a chance to show how good you are at asking questions. In the spaces below write down all of the questions you can think of about the things you see in the picture. Ask the questions you would need to know to understand what is happening. Do not ask questions which can be answered by looking at the picture.

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h. Task VII. GUESS CAUSES

In the spaces below, list as many possible things as you can which might have caused the action shown in the picture. You may use things that might have happened just before the event in the picture, or something that happened a long time ago that had an influence on the present event. Make as many guesses as you can. Don't be afraid to guess.

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i. Task VIII. GUESS CONSEQUENCES

In the space below, list as many possibilities as you can of what might happen as a result of what is happening in the picture. You may use things that might happen right afterwards or things that might happen as a result long afterwards in the future. Make as many guesses as you can. Don't be afraid to guess.

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APPENDIX B

DIRECTIONS FOR ADMINISTERING
CONCEPT FORMATION TASKS

A. Reception Tasks

Here are some cards similar to those which we will be working with. You will notice that no two cards are exactly the same, although each card has something in common with one or more of the other cards. Some of the cards are printed in green, others in red, and others in black. Each of the cards has a figure and two letters on it; as you see the figure may be a triangle, a square, or a circle. One of the letters is a capital letter: A, B, or C. The other letter is a small letter: small a or b or c. It is possible to read each card, for example this one (show Gr O Bc) is green, has a circle, a capital B and a small c; this one (show Red □ Aa) is red, has a square, a capital A and a small a. Are there any questions so far? (Answer questions dealing with relevant variables and how they may be read).

These cards can be grouped into classes. Suppose, for instance, I choose 'Red' Circle! Several of the cards have a red circle drawn on them. (Show examples) Thus they belong to the class I have chosen. They are all positive instances of the class. Whenever I say that a card is a positive instance I mean that it belongs to the class I have chosen. There will also be cards that do not belong to the class. For example, these cards (show) do not have red circles drawn on them. Therefore they cannot belong to the class of cards

having red circles. These cards are all negative instances. Whenever I say that a card is a negative instance I mean that it does not belong to the class I have chosen.

To be sure that you understand what I mean I shall give you another example. I choose the class, 'Red square, small b'. Is this card a positive or a negative instance? (Show eight cards, including two positive and six negative instances, the negative instances being so chosen that some of them include part of the class definition. Wait for answers and correct if wrong.) Now I am sure that you all understand what is meant by positive and negative instances because they belong to the class I have chosen. These six cards (show) are negative instances because they do not belong to the class I have chosen.

I shall now tell you what I want you to do for me. I am going to give you a series of problems to solve. Each time I shall choose a class of cards and ask you to find out what class I have chosen. To help you to arrive at the answer I shall show you six cards in order and tell you with each card whether it is a positive or a negative instance. I shall show each card for twenty seconds. On the desk in front of you there is an answer sheet. (Direct attention of each subject to answer sheet). When you have seen the first card I want you to write in the space numbered 1 on your answer sheet: A description of the class you think I have chosen. You may

do this in words or use the abbreviations on the code sheet. (Direct attention of each subject to code sheet and give examples of use of each abbreviation.) I shall follow the same procedure with each of the other five cards, and you will write down on your answer sheet in the appropriate place your description of the class. You are free at any time either to repeat an earlier description or to change it. You may, in fact, find that you do not need to see six cards to identify the class I have chosen. I have already directed your attention to the abbreviation on the code sheet. Now I also want you to use the code sheet in another way. When you have seen the first card and written your description of the class I have chosen, I want you to cover up this description with the code sheet. As you write further description, I want you to slide the code sheet down over the answer sheet so that they are also covered up. You must not lift the code sheet at any time to refer back to an earlier description. Be sure to write down what you think I have in mind after each number on the answer sheet, as soon as you can after a card is presented. Then pull down the code sheet so that it just covers what you have written. When the next card is presented you will be ready to write your answer in the appropriate place on the answer sheet.

We are now ready to begin the first problem. (The concept sought was green,circle, capital B). Write your name

on your answer sheet and also write number 1 in the top right hand corner of the page. Now place your code sheet so that it is just above the number 1.

This is the first card and it is positive. (Expose card Gr O Bb for twenty seconds and allow a ten second lapse before showing the next card. When removing card say:) Write down what class you think I have in mind. Remember to slide down your code sheet. (Present second card.)

This card (BkΔCb) is negative. (20 seconds). Write down what you think I have in mind. (10 seconds). Pull down your code sheet.

This card (Bk□Bb) is negative (20 seconds. Write down exactly what you think I have in mind. (10 seconds).

This card(R□Ab) is negative, and so on.

This card (GrOBa) is positive, and so on.

This card (GrOBc) is positive, and so on.

Remove the answer sheet you have just completed and write your name and number 2 on the second sheet. We are now ready to do problem number two. (Concept sought : Capital A)

This card (GrOAc) is positive

This card (Gr□Ac)is positive

This card (Bk□Bc) is negative

This card (R□Bc) is negative

This card (BkOCb) is negative

This card (ROAa) is positive

Write your name and the number 3 on the next answer sheet. Now we will do problem three. (Concept sought: Triangle small a).

This card (R△Cc) is positive
This card (Gr△Cb) is negative
This card (BkOBa) is negative
This card (R△Bc) is positive
This card (Gr□Cb) is negative
This card (Bk△Ac) is positive

Place the three answer sheets and the code sheet number one to one side of your desk.

Now look at code sheet number two. This sheet will be used with the next three problems. The cards we will now be using each have a bird on them. (Show examples). As before each card is in some way different from all other cards. Also as before the cards can be grouped into classes. Again I will select a class which you will try to discover from the six cards which I will show you. Your code sheet tells you what features are important. The birds may be yellow, red, or blue. Some are flying, others standing and others perching. Some are large, some are medium, and others small. Also the borders around the bird are not all alike. These have a closed border, these have borders that are open on the side and these are open at the corners. (During the discussion on relevant attributes illustrate each by examples). Study your code sheet. (One minute)

Now let us begin problem four. (Concept sought: medium). Write your name and the number 4 on the sheet and slide your code sheet, number two, so that it just covers what you have written.

This card (MYStOS) is positive
This card (MR Fly OS) is positive
This card (LR Per Cl) is negative
This card (LY Fly OC) is negative
This card ((M Be St Cl) is positive
This card (SY Fly OC) is negative

Write your name and number 5 on the next answer sheet and place your code sheet as before. (Concept sought: large, blue, flying).

This card (L Be Fly OC) is positive
This card (MR St OC) is negative
This card (L Be St Cl) is negative
This card (L Be Fly Cl) is positive
This card (L Be Fly OS) is positive
This card (SY St OC) is negative

Write your name and the number 6 on the next sheet and place your code sheet as before. (Concept sought: small, closed border).

This card (S Be Fly Cl) is positive
This card(L Be St OC) is negative
This card (MY Per OC) is negative
This card (S Be St Cl) is positive
This card (S R Per Cl) is positive
This card (S R Fly OC) is negative

Now set aside code sheet number two and the six answer sheets completed so far.

The next three problems are done with cards showing a young man's face. (Show examples). Again I shall choose a class and you will try to discover what I have in mind from the six examples which I show you. Look at code sheet number three. The man may have fair hair, black, or brown hair. Notice that his tie may be blue, red, or black. He may have both eyes open or the right eye open or the left eye open. Also he may be shown facing you or looking to the left or to the right. (Illustrate attributes with examples). Study your code sheet. (Allow one minute).

Write your name and the number 7 on the next sheet. Pull your code sheet three over the answer sheet. (Concept sought: fair hair, left view of face).

Here is the first card (FH Left BeT BO), this card is positive.

This card (BkH Left BkT BO) is negative

This card (FH Left BeT RO) is positive

This card (BkH Left BkT RO) is negative

This card (BkH Right BkT BO) is negative

This card (FH Left BkT LO) is positive

Now write your name and the number 8 on the next sheet. (Concept sought: Right view of face, right eye open, blue tie). Slide the code sheet into position.

This card (BrH Right RO BeT) is positive

This card (BkH Right BO BeT) is negative

This card (BrH Front RO RT) is negative

This card (FH Right RO BeT) is positive

This card (FH Front BO BeT) is negative

This card (BkH Right RO BeT) is positive

Write your name and the number 9 on the next answer sheet. (Concept sought: red tie). Slide the code sheet into position.

This card (BkH Right RO RT) is positive

This card (BkH Left RO RT) is positive

This card (FH Front LO BeT) is negative

This card (FH Right LO BkT) is negative

This card (BrH Left BO BeT) is negative

This card (FH Left BO RT) is positive

Leave all the answer sheets and the code sheets on your desk. I want to again thank you for co-operating with me and I hope you enjoyed trying to solve the problems.

B. Selection Tasks

You see before you 81 cards each of which is different from every other card. Each card is made up of four distinctive features, for example, this card (Gr O Bb) is printed in green, has a circle, a capital B and a small b. In all there are twelve distinctive features combined in groups of four in such a way that all possible combinations are presented on the cards before you. Code sheet number one indicates that these twelve features may be grouped under the headings of color, figure, capital and small letters. Study the code sheet. The three colors are red, black, and green; the figures are triangle, square, and circle; the capital letters are capital A, capital B, and capital C; and the small letters are small a, small b, and small c. (Allow one minute to study Code Sheet). Now what do you see in this card? (Student responds--repeat examples until he gets two consecutive correct answers).

These cards can be grouped into classes. if the class I have in mind is capital A, small a, then these (pointing) are positive because each of these contains both A and a. These cards (pointing) are negative. These (pointing) are negative because neither capital A nor small a is present and these because they have only one of the features I have in mind. Suppose the class I am thinking of is 'red'. Point out positive instances. (Time). Point out negative instances. (Time).

Suppose I am thinking of Green Ca, point out positive and negative instances. Fine.

Now I am going to choose a class and by making choices you will try to discover what class I have chosen. For example, suppose I choose the class Ab, I will not tell you which class I choose; instead I will point to a card that has both the A and the b and will say only: "this card is positive." Then you will tell me what you think I have in mind. After this you will select cards which you think will help you to figure out what class I have chosen. When you choose a card I will tell you whether it is positive or negative and you will tell me what you now think I have in mind.

Now I have chosen a class. (Concept sought: black triangle capital B). This (BkΔBa) is a positive instance of the class I have in mind. Tell me what class you think I have chosen. (Time). Now you choose a card which you feel will help you. (Choice is confirmed or denied by examiner). What class do you think I have in mind? (Continue until problem is solved when the subject has identified the concept).

Now I will choose another class. (Concept sought: capital C). This (Red O Cb) is a positive example. "Tell me what class you think I have chosen. (Time). Now you choose a card which you feel will help you. (Choice is confirmed or denied by examiner). What class do you think I have in mind? (Continue until problem is solved when the subject has identified the concept)."

Again I have chosen a class. (Concept sought: square, small b). This card (Green□Ab) is positive. "Tell me what class you think I have chosen. (Time). Now you choose a card which you feel will help you. (Choice is confirmed or denied by examiner). What class do you think I have in mind? (Continue until problem is solved when the subject has identified the concept)."

Here, we have another set of 81 cards. Again each card is different from each other card. Also as before the cards can be grouped into classes. I will choose a class and you will try to select cards which will help you to discover what class I have chosen. Study code sheet number 2. The birds on these cards may be yellow, red, or blue; (point out examples) they may be large, medium, or small; (example) they may be flying, perched, or standing; (examples) and the border around the bird may be closed or it may be open either on the sides or at the corners. (Examples). Study the code sheet. (One minute).

What do you see in this card? (Continue until two correct). You remember what we meant by positive and negative. If I choose a class "Blue" show me positive and negative instances.

Now I will choose a class. (Concept sought: large, flying). This card (L.Be Fly OS) is positive. "Tell me what class you think I have chosen. (Time). Now you choose a card

which you feel will help you. (Choice is confirmed or denied by examiner). What class do you think I have in mind? (Continue until problem is solved when the subject has identified the concept)."

Now I have chosen another class. (Concept sought: blue, standing, closed border). This card (S.Ba St Cl) is a positive instance. "Tell me what class you think I have chosen. (Time). Now you choose a card which you feel will help you. (Choice is confirmed or denied by examiner). What class do you think I have in mind? (Continue until problem is solved when the subject has identified the concept)."

Again I have chosen a class. (Concept sought: open corner border). This card (M Y OC Per) is a positive instance. "Tell me what class you think I have chosen. (Time). Now you choose a card which you feel will help you. (Choice is confirmed or denied by examiner). What class do you think I have in mind? (Continue until problem is solved when the subject has identified the concept)."

This is the third set of 81 different cards. The third code sheet tells us what the distinctive features are. The color of the hair may be fair, black, or brown; (examples) the tie may be blue, black, or red;(examples) the eyes may be open, or the left eye open, or the right eye open; (examples) and finally the head may be turned to the left or to the right or facing directly forward; (examples). Study the code sheet. (One minute).

I have chosen a class. (Concept sought: fair hair, both eyes open). This card (FH BeT Left BO) is a positive instance. "Tell me what class you think I have chosen. (Time). Now you choose a card which you feel will help you. (Choice is confirmed or denied by examiner). What class do you think I have in mind? (Continue until problem is solved when the subject has identified the concept)."

Now I have chosen another class. (Concept sought: brown hair). This card (BrH RT Full LC) is a positive instance. "Tell me what class you think I have chosen. (Time). Now you choose a card which you feel will help you. (Choice is confirmed or denied by examiner). What class do you think I have in mind? (Continue until problem is solved when the subject has identified the concept)."

Again I have chosen a class. (Concept sought: right view of head, left eye open, red tie). This card (BkH Right LO RT) is a positive example. "Tell me what class you think I have chosen. (Time). Now you choose a card which you feel will help you. (Choice is confirmed or denied by examiner). What class do you think I have in mind? (Continue until problem is solved when the subject has identified the concept)."

That completes our visit. I wish, again to thank you for your help in this project.

In the meantime, the examiner records everything the subject says: questions, classes suggested or eliminated, and repetition of directions requested. The time required between choices and the sequence of choices is also carefully kept.

APPENDIX C

SCORING KEYS

A. Concept Formation Tasks

1. Reception tasks

In reception tasks the sequence of instances varied from task to task but did not vary for a given task. The scoring keys for each of the nine tasks are given on the following pages. The sequence of positive and negative instances for each task was presented in the order indicated reading from left to right. Each attribute in the subjects' responses are indicated by a plus or minus sign (plus if the attribute is still tenable and minus if the attribute is no longer tenable. All possible combinations of four or fewer attributes and the value assigned to each are given. The amount of information available from each instance is also indicated. The figures given in the body of the scoring keys are products of the values assigned to the responses and the amount of information (in bits) for any given response on any given instance on any given task.

RECEPTION TASK ONE SCORING KEY (CONCEPT SOUGHT: GrOB)

Instance		GrOBb	BkΔCb	Bk□Bb	R□Ab	GrOBa	GrOBc
Positive or Negative		Pos.	Neg.	Neg.	Neg.	Pos.	Pos.
Responses	Values						
++++	15	61.305	1.500	3.330		15	
+++-	5.86	23.938	.586	1.300		5.857	
++--	-1	-4.087	-.100	-.222		-1	
+---	-13	-53.131	-1.300	-2.886		-13	
----	-15	-61.305	-1.500	-3.33		-15	
+++	7	28.609	.700	1.554		7	
++-	1.67	6.812	.167	.370		1.670	
+--	-5	-20.435	-.500	-1.110		-5	
---	-7	-28.609	-.700	-1.554		-7	
+-	3	12.261	.300	.666		3	
++	-1	-4.087	-.100	-.222		-1	
--	-3	-12.261	.300	.666		-3	
+	1	4.087	.100	.222		1	
-	-1	-4.087	-.100	-.222		-1	
Information Bits		4.087	.100	.222	0	1	0

RECEPTION TASK TWO SCORING KEY (CONCEPT SOUGHT: Capital A)

Instance		GrOAc	Gr□Ac	Bk□Be	R□Be	BkOCb	ROAa
Positive or Negative		Pos.	Pos.	Neg.	Neg.	Neg.	Pos.
Responses	Values						
++++	15	61.305	16.500	3.330			
+++-	5.86	23.938	6.443	1.300			
++--	-1	-4.087	-1.100	-.222			
+---	-13	-53.131	-14.300	-2.886			-33.605
----	-15	-61.305	-16.500	-3.330			
+++	7	28.609	7.700	1.554			
++-	1.67	61.812	1.833	.370			4.308
+--	-5	-20.435	-5.500	-1.110			-12.925
---	-7	-28.609	-7.700	-1.554			
++	3	12.261	3.300	.666			
+-	-1	-4.087	-1.100	-.222			
--	-3	-12.261	-3.300	-.666			
+	1	4.087	1.100	.222			2.585
-	-1	-4.087	-1.100	-.222			
Information Bits		4.087	1.100	.222	0)	0	2.585

RECEPTION TASK THREE SCORING KEY (CONCEPT SOUGHT: small c)

Instances		R△Cc	Gr△Cb	Bk○Ba	R△Bc	Gr□Cb	Bk△Ac
Positive or Negative		Pos.	Neg.	Neg.	Pos.	Neg.	Pos.
Responses	Values						
++++	15	61.305	4.830				
+++-	5.86	23.938	1.886		5.857		
++--	-1	-4.187	-.322		-1		-1.585
+---	-13	-53.131	-4.186		-13		-20.605
----	-15	-61.305	-4.830		-15		-23.775
+++	7	28.609	2.244		7		
++-	1.67	6.812	.537		1.667		2.642
+--	-5	-20.435	-1.610		-5		-7.925
---	-7	-28.609	-2.244		-7		-11.095
++	3	12.261	.966				4.755
+-	-1	-4.087	-.322		-1		-1.585
--	-3	-12.261	-.966		-3		-4.755
+	1	4.087	.322		1		1.585
-	-1	-4.087	-.322		-1		-1.585
Information Bits		4.087	.322	0	1	0	1.585

RECEPTION TASK FOUR SCORING KEY (CONCEPT SOUGHT: M

Instances		MYSt.OS	MR Fly OS	LR Per Cl	LY Fly OC	MBe St Cl	SY Fly OC
Positive or Negative		Pos.	Pos.	Neg.	Neg.	Pos.	Neg.
Responses	Values						
++++	15	61.305					
+++-	5.86	23.938					
++--	-1	-4.087	-2.322				
+---	-13	-53.131	-30.186			-20.605	
----	-15	-61.305	-34.830			-23.775	
+++	7	28.609					
++-	1.67	6.812	3.870				
+--	-5	-20.435	-11.610			-7.925	
---	-7	-28.609	-16.284			-11.095	
++	3	12.261	6.966				
+-	-1	-4.087	-2.322			-1.585	
--	-3	-12.261	-6.966			-4.755	
+	1	4.087	2.322			1.585	
-	-1	-4.087	-2.322	0	0	-1.585	
Information Bits		4.087	2.322	0	0	1.585	0

RECEPTION TASK FIVE SCORING KEY (CONCEPT SOUGHT: L Be Fly)

Instances		L Be Fly OC	MR St OC	LBe St Cl	L Be Fly Cl	LBeFlyOS	SYSTOC
Positive or Negative		Pos.	Neg.	Neg.	Pos.	Pos.	Neg.
Responses	Values						
++++	15	61.305	1.50	6.720			
+++-	5.86	23.938	.586	2.624	8.546		
++--	-1	14.087	-.100	-.448	-1.459		
+---	-13	-53.131	-1.300	-5.824	-18.967		
----	-15	-61.305	-1.500	-6.720	-21.885		
+++	7	28.609	.700	3.136	10.213		
++-	1.67	6.812	.167	.747	2.432		
+--	-5	-20.435	-.500	-2.240	-7.295		
---	-7	-28.609	-.700	-3.136	-10.213		
++	3	12.261	.300	1.344	4.377		
+-	-1	-4.087	-.100	-.448	-1.459		
--	-3	-12.261	-.300	-1.344	-4.377		
+	1	4. 087	.100	.448	1.459		
-	-1	-4.087	-.100	-.448	-1.459		
Information Bits		4.087	.100	.448	1.459	0	0

RECEPTION TASK SIX SCORING KEY (CONCEPT SOUGHT: S Cl)

Instances		S Be Fly Cl	LBE St OC	MY Per OC	SBe St Cl	SR PerCL	SRFlyOC
Positive or Negative		Pos.	Neg	Neg.	Pos.	Pos.	Neg.
Responses	Values						
++++	15	61.305	1.500				
+++-	5.86	23.938	.586		7.157	5.860	3.426
++--	-1	-4.087	-.100		-1.222	-1	-5.585
+---	-13	-53.131	-1.300		-15.886	-13	-7,605
----	-15	-61.305	-1.500		-18.330	-15	-8.775
+++	7	28.609	.700		8.554	7	4.095
++-	1.67	6.812	.167		2.037	1.667	.975
+--	-5	-20.435	-.500		-6.110	-5	-2.925
----	-7	-28.609	-.700		-8.554	-7	4.095
++	3	12.261	.300		3.666	3	1.755
+-	-1	-4.087	-.100		-1.222	-1	-. 585
--	-3	-12.261	-.300		-3.666	-3	-1.755
+	1	4.087	.100		1.222	1	.585
-	-1	-4.087	-.100		-1.222	-1	-.585
Information Bits		4.087	.100	0	1.222	1	.585

RECEPTION TASK SEVEN SCORING KEY (CONCEPT SOUGHT: F.H.Left)

Instances		FH Left BeT BO	BkH Left BkT BO	FH Left BeT RO	BkH Left Bk T RO	BkH Right Bk T BO	FH Left Bk T LO
Positive or Negative		Pos.	Neg.	Pos.	Neg.	Neg.	Pos.
Res-ponses	Values						
++++	15	61.305	4.830				
+++-	5.86	23.938	1.886	5.857			
++--	-1	-4.087	-.322	-1			-1.585
+---	-13	-53.131	-4.186	-13			-20.605
----	-15	-61.305	-4.830	-15			-23.775
+++	7	28,609	2,254	7			
++-	1.67	6.812	.537	1.667			2.645
+--	-5	-20.435	-1.610	-5			-7.925
---	-7	-28.609	-2.254	-7			-11.095
++	3	12.261	.996	3			4.755
+-	-1	-4.087	-.322	-1			-1.585
--	-3	-12.261	-.966	-3			-4.755
+	1	4.087	.322	1			1.585
-	-1	-4.087	-.322	-1			-1.585
Information Bits		4.087	.322	1	0	0	1.585

RECEPTION TASK EIGHT SCORING KEY (CONCEPT SOUGHT:Right RO BeT)

Instances		Br H Right RO Be T	Bk H Right BO Be T	Br H Front RO RT	FH Right RO BeT	FH Front BO Be T	Bk H Right RO Be T
Positive or Negative		Pos.	Neg.	Neg.	Pos	Neg.	Pos
Res-ponses	Values						
++++	15	61.305	4.830	6.225			
+++-	5.86	23.938	1.886	2.431	9.284		
++--	-1	-4.087	-.322	-.415	-1.585		
+---	-13	-53.131	-4.186	-5.395	-20.605		
----	-15	-61.305	-4.830	-6.225	-23.775		
+++	7	28.609	2.254	2.905	11.095		
++-	1.67	6.812	.537	.692	2.642		
+--	-5	-20.435	-1.610	-2.075	-7.925		
---	-7	-28.609	-2.254	-2.095	-11.095		
++	3	12.261	.966	1.245	4.755		
+-	-1	-4.087	-.322	-.415	-1.585		
--	-3	-12.261	-.966	-1.245	-4.755		
+	1	4.087	.322	.415	1.585		
-	-1	-4.087	-.322	-.415	-1.585		
Information Bits		4.087	.322	.415	1.585	0	0

RECEPTION TASK NINE SCORING KEY (CONCEPT SOUGHT: R.T.)

Instances		Bk H Right RO RT	Bk H Left RO RT	FH Front LO Be T	FH Right LO Bk T	Br H Left BO Be T	FH Left BO R.T.
Positive or Negative		Pos.	Pos.	Neg.	Neg.	Neg.	Pos.
Responses	Values						
++++	15	61.305					45
+++-	5.86	23.938	5.312				17.569
++--	-1	-4.087	-.907				-3
+---	-13	-53.131	-11.791				-39
----	-15	-61.305	-13.605				-45
+++	7	28.609	6.349				21
---	1.67	6.812	1.512				4
+--	-5	-20.435	-4.535				-15
---	-7	-28.609	-6.349				-21
++	3	12.261	2.721				9
+-	-1	-4.087	-.907				-3
--	-3	-12.261	-2.271				-9
+	1	4.087	.907				3
-	-1	-4.087	-.907				-3
Information Bits		4.087	.907	0	0	0	3

SELECTION TASK SCORING KEY

255 Tenable Hypotheses

Responses	Values	
++++	15	61.305
+++-	5.86	23.938
++--	-1	-4.087
+---	-13	-53.131
----	-15	-61.305
+++	7	28.609
++-	1.67	6.812
+--	-5	-20.435
---	-7	-28.609
++	3	12.261
+-	-1	-4.087
--	-3	-12.261
+	1	4.087
-	-1	-4.087
Information Bits		4.087
Number of hypotheses remaining after initial positive instance.	15	

Selection Tasks

The total number of possible tenable hypothses is 255 for each set of cards. The presentation of an initial positive instance reduces to fifteen the number of tenable hypotheses. The remaining cards chosen by the subject may or may not further reduce the number of tenable hypotheses. The amount of information (in bits) contained in a vard is dependent on the number of hypothses it eliminates. To determine the amount of information contained in a card the examiner must know the number of tenable hypothses that remain both before and after the card is selected. Also, he must know the value assigned to the subject's response to the card. The product of 'amount of information' and'value assigned' is the score on a response . The scoring key indicates, at the top, the number of tenable hypotheses that remain before a card is chosen and at the bottom the number that remains after a card is chosen. The response and their respective values are indicated in the first and second vertical columns respectively. The score for a response is found where the response value row meets the amount of information column. The scoring key for selection tasks is given on the following pages.

Responses	Values				15 Tenable Hypotheses		
++++	15	1.500	4.830	13.605	16.500	34.830	58.605
+++-	5.86	.586	1.886	5.312	6.446	13.607	22.883
++--	-1	-.100	-.322	-.907	-1.100	-2.322	-3.907
+---	-13	-1.300	-4.186	-11.791	-14.300	-30.186	-50.791
----	-15	-1.500	-4.830	-13.605	-16.500	-34.830	-58.605
+++	7	.700	2.254	6.349	7.700	16.254	27.349
++-	1.67	.167	.537	1.512	1.837	3.870	6.525
+--	-5	-.500	-1.610	-4.535	-5.500	-11.610	-19.535
---	-7	-.700	-2.254	-6.349	-7.700	-16.254	-27.349
++	3	.300	.966	2.721	3.300	6.966	11.721
+-	-1	-.100	-.322	-.907	-1.100	-2.322	-3.907
--	-3	-.300	-.966	-2.271	-3.300	-6.966	-11.721
+	1	.100	.322	.907	1.100	2.322	3.907
-	-1	-.100	-.322	-.907	-1.100	-2.322	-3.907
Information Bits	0	.100	.322	.907	1.100	2.322	3.907
Number of Tenable Hypotheses Remaining after Card is Chosen.	15	14	12	8	7	3	1

14 TENABLE HYPOTHESES

Responses	Values									
++++	15	1.605	3.330	5.220	12.105	15	18.330	33.330	42.105	57.105
+++-	5.86	.625	1.300	2.038	4.726	5.856	7.156	13.012	16.441	22.294
++--	-1	-.107	-.222	-.348	-.807	-1	-1.222	-2.222	-2.807	-3.807
+---	-13	-1.391	-2.886	-4.524	-10.491	-13	-15.886	-28.886	-36.491	-49.491
----	-15	-1.605	-3.330	-5.220	-12.105	-15	-18.330	-33.330	-42.105	-57.105
+++	7	.749	1.554	2.436	5.649	7	8.554	15.554	19.649	26.649
++-	1.67	.179	.371	.581	1.348	1.67	2.041	3.711	4.688	6.358
+--	-5	-.535	-1.110	-1.740	-4.035	-5	-6.110	-11.110	-14.035	-19.035
---	-7	-.749	-1.554	-2.436	-5.649	-7	-8.554	-15.554	-19.649	-26.649
++	3	.321	.666	1.044	2.421	3	3.666	6.666	8.421	11.421
+-	-1	-.107	-.222	-.348	-.807	-1	-1.222	-2.222	-2.807	-3.807
--	-3	-.321	-.666	-1.044	-2.421	-3	-3.666	-6.666	-8.421	-11.421
+	1	.107	.222	.348	.807	1	1.222	2.222	2.807	3.807
-	-1	-.107	-.222	-.348	-.807	-1	-1.222	-2.222	-2.807	-3.807
Information Bits	0	.107	.222	.348	.807	1	1.222	2.222	2.807	3.087
Number of tenable hypotheses remaining after choice is made.	14	13	12	11	8	7	6	3	2	1

13 TENABLE HYPOTHESES

Responses	Values									
++++	15	1.725	3.615	5.670	10.500	16.725	20.670	31.725	40.500	55.500
+++-	5.86	.673	1.403	2.214	4.099	6.519	8.070	12.385	15.787	21.767
++--	-1	-.115	-.241	-.378	-.700	-1.115	-1.378	-2.115	-2.700	-3.700
+---	-13	-1.495	-3.133	-4.914	-9.100	-14.495	-17.914	-27.495	-35.100	-48.100
----	-15	-1.725	-3.615	-5.670	-10.500	-16.725	-20.670	-13.725	-40.500	-55.500
+++	7	.805	1.687	2.546	4.900	7.805	9.646	14.805	18.900	25.900
++-	1.67	.192	.402	.419	1.169	1.862	2.370	3.532	4.501	6.179
+--	-5	-.575	-1.205	-1.890	-3.500	-5.575	-6.890	-10.575	-13.500	-18.500
---	-7	-.805	-1.687	-2.546	-4.900	-7.805	-9.646	-14.805	-18.900	-25.900
++	3	.345	.723	1.134	2.100	3.345	4.134	6.345	8.100	11.100
+-	-1	-.115	-.241	--.378	--.700	-1.115	-1.378	-2.115	-2.700	-3.700
--	-3	-.345	-.723	-1.134	-2.100	-3.345	-4.134	-6.345	-8.100	-11.100
+	1	.115	.241	.378	.700	1.115	1.378	2.115	2.700	3.700
-	-1	-.115	-.241	-.378	-.700	-1.115	-1.378	-2.115	-2.700	-3.700
Information Bits	0	.115	.241	.378	.700	1.115	1.378	2.115	2.700	3.700
Number of tenable hypotheses remaining after choice made	13	12	11	10	8	6	5	3	2	1

12 TENABLE HYPOTHESES

Responses	Values									
++++	15	1.890	3.945	6.225	8.775	18.945	23.775	30	38.775	53.765
+++-	5.86	.738	1.540	2.431	3.426	7.396	9.284	11.712	15.138	20.384
++--	-1	-.126	-.263	-.415	-.585	-1.263	-1.585	-2.000	-2.585	-3.585
+---	-13	-1.638	-3.419	-5.395	-7.605	-16.419	-20.605	-26.000	-33.605	-46.605
----	-15	-1.890	-3.945	-6.225	-8.775	-18.945	-23.775	-30.000	-38.775	-53.765
+++	7	.882	1.841	2.905	4.095	8.838	11.095	14.000	18.095	25.095
++-	1.67	.210	.439	.692	.975	1.013	2.642	3.340	4.317	5.987
+--	-5	.630	1.315	-2.075	-2.925	-6.315	-7.925	-10.000	-12.925	17.915
---	-7	-.882	-1.841	-2.095	-4.095	-8.838	-11.095	-14.000	-18.095	-25.095
++	3	.378	.789	1.245	1.755	3.789	4.755	6.000	7.755	10.755
+-	-1	-.126	.263	-.415	-.585	-1.263	-1.585	-2.000	-2.585	-3.585
--	-3	-.378	-.789	- 1.245	-1.755	-3.789	-4.755	-6.000	-7.755	-10.755
+	1	.126	.263	.415	.585	1.263	1.585	2.000	2.585	3.585
-	-1	-.126	-.263	-.415	-.585	-1.263	-1.585	-2.000	-2.585	-3.585
Information Bits	0	.126	.263	.415	.585	1.263	1.585	2.000	2.585	3.585
Number of tenable hypotheses remaining after choice is made	12	11	10	9	8	5	4	3	2	1

11 TENABLE HYPOTHESES

Responses	Values										
++++	15	2.055	4.335	6.885	9.780	13.110	17.055	21.885	28.110	36.885	51.885
+++-	5.86	.801	1.692	2.688	3.818	5.118	6.658	8.544	10.974	14.399	20.256
++--	-1	-.137	-.289	-.459	-.652	-.874	-1.137	-1.459	-1.874	-2.459	-3.459
+---	-13	-1.781	-3.757	-5.967	-8.476	-11.362	-14.781	-18.967	-24.362	-3.967	-44.967
----	-15	-2.055	-4.335	-6.885	-9.780	-13.110	-17.055	-21,885	-28.110	-36.885	-51.885
+++	7	.959	2.023	3.213	4.564	6.118	7.959	10.213	-3.180	17.213	24.213
++-	1.67	.259	4.826	.767	.989	.753	1.899	2.437	3.130	4.107	5.777
+--	-5	-.685	-1.445	-2.295	-3.260	-4.370	-5.685	-7.295	-9.370	-12.295	-17.295
---	-7	-.959	-2.023	-3.213	-4.564	-6.118	-7.959	-10.213	-13.118	-17.213	-24.213
++	3	.411	.867	1.377	1.956	2.622	3.411	4.377	5.622	7.377	10.377
+-	-1	-.137	.289	-.459	-.652	-.874	-1.137	-1.459	-1.874	-2.459	-3.459
--	-3	-.411	-.867	-1.377	-1.956	-2.622	-3.411	-4.377	-5.622	-7.377	-10.377
+	1	.137	.289	.459	.652	.874	1.137	1.459	1.874	2.459	3.459
-	-1	-.137	-.289	-.459	-.652	-.874	-1.137	-1.459	-1.874	-2.459	-3.459
Information Bits	0	.137	.289	.459	.652	.874	1.137	1.459	1.874	2.459	3.459
Number of tenable hypotheses remaining after choice is made.	11	10	9	8	7	6	5	4	3	2	1

10 TENABLE HYPOTHESES

Responses	Values								
++++	15	2.280	4.830	7.725	11.055	19.830	26.055	34.830	49.830
+++-	5.36	.890	1.886	3.016	4.314	7.742	10.172	13.607	19.461
++--	-1	-.152	-.322	-.515	-.737	-1.322	-1.737	-2.322	-3.322
+---	-13	-1.976	-4.186	-6.695	-9.581	-17.186	-22.601	-30.186	-43.186
----	-15	-2.280	-4.830	-7.725	-11.055	19.830	-26.055	-34.830	-49.830
+++	7	1.064	2.254	3.605	5.159	9.254	12.159	16.254	23.254
++-	1.67	.254	.537	.860	1.275	2.208	2.901	3.870	6.208
+--	-5	-.760	-1.610	-2.575	-3.685	-6.610	-8.685	-11.610	-16.610
---	-7	-1.064	-2.254	-3.605	-5.159	-9.254	-12.159	-16.254	-23.254
++	3	.456	.966	1.545	2.211	3.966	5.211	6.966	9.966
+-	-1	-.152	-.322	-.515	-.737	-1.322	-1.737	-2.322	-3.322
--	-3	-.456	-.966	-1.545	-2.211	-3.966	-5.211	-6.966	-9.966
+	1	.152	.322	.515	.737	1.322	1.737	2.322	3.322
-	-1	-.152	-.322	-.515	-.737	- 1.322	-1.737	-2.322	-3.322
Information Bits	0	.152	.322	.515	.737	1.322	1.737	2.322	3.322
Number of tenable hypotheses remaining after choice is made	10	9	8	7	6	4	3	2	1

9 TENABLE HYPOTHESES

Responses	Values						
++++	15	2.550	8.775	12.720	17.550	23.775	47.550
+++-	5.86	.996	3.426	4.197	6.848	9.284	18.560
++--	-1	-.170	-.585	-1.848	-1.170	-1.585	-3.170
+---	-13	-2.210	-7.605	-11.024	-15.210	-20.605	-41.210
----	-15	-2.550	-8.775	-12.720	-17.550	-23.775	-47.550
+++	7	1.190	4.095	5.936	-8.190	11.095	22.190
++-	1.67	.284	.975	1.416	1.954	2.642	5.290
+--	-5	-.850	-2.925	-4.240	-5.850	-7.925	15.850
---	-7	-1.190	-4.095	-5.936	-8.190	-11.095	-22.190
++	3	.510	1.755	2.544	3.510	4.755	9.510
+-	-1	-.170	- .585	-.848	-1.170	-1.585	-3.170
--	-3	-.510	-1.755	-2.544	-3.510	-4.755	-9.510
+	1	.170	.585	.848	1.170	1.585	3.170
-	-1	-.170	-.585	-.848	-1.170	-1.585	-3.170
Information Bits	0	.170	.585	.848	1.170	1.585	3.170
Number of tenable hypotheses remaining after choice is made.	9	8	6	5	4	3	1

8 TENABLE HYPOTHESES

Responses	Values						
++++	15	2.895	6.225	15	21.125	30	45
+++-	5.86	1.130	2.431	5.857	8.290	11.720	17.580
++--	-1	-.193	-.415	-1.000	-1.415	-2.000	-3.000
+---	-13	-2.509	-5.395	-13.000	-18.395	-26.000	-39.000
----	-15	-2.895	-6.225	-15.000	-21.125	-30.000	-45.000
+++	7	1.351	2.905	7.000	9.905	14.000	21.000
++-	1.67	.322	.692	1.670	1.598	3.340	5.010
+--	-5.	9.650	-2.075	-5.000	-7.075	-10.000	-15.000
---	-7	-1.351	-2.095	-7.000	-9.905	-14.000	-21.000
++	3	.579	1.245	3.000	4.245	6.000	9.000
+-	-1	-.193	-.415	-1.000	-1.415	-2.000	-3.000
--	-3	-.579	-1.245	-3.000	-4.245	-6.000	-9.000
+	1	.193	.415	1.000	1.415	2.000	3.000
-	-1	-.193	-.415	-1.000	-1.415	-2.000	-3.000
Information Bits	0	.193	.415	1.000	1.415	2.000	3.000
Number of tenable hypotheses remaining after choice is made.	8	7	6	4	3	2	1

7 TENABLE HYPOTHESES

Responses	Values						
++++	15	3.330	7.275	12.105	18.330	27.105	42.105
+++-	5.86	1.300	2.842	4.726	7.156	10,582	16.441
++--	-1	-.222	-.485	-.807	-1.222	-1.807	-2.807
+---	-13	-2.886	-6.305	-10.491	-15.886	-23.491	-36.491
----	-15	-3.330	-7.275	-12.105	-18.330	-27.105	-42.105
+++	7	1.554	3.395	5.649	8.554	12.649	19.649
++-	1.67	.371	.810	1.348	2.041	3.018	4.688
+--	-5	-1.110	-2.425	-4.035	-6.110	-9.035	-14.035
---	-7	-1.554	-3.395	-5.649	-8.554	-12.649	-19.649
++	3	.666	1.455	2.421	3.666	5.421	8.421
+-	-1	-.222	-.485	-.807	-1.222	-1.807	-2.807
--	-3	-.666	-1.455	-2.421	-3.666	-5.421	-2.241
+	1	.222	.485	.807	1.222	1.807	.807
-	-1	-.222	-.485	-.807	-1.222	-1.807	-.807
Information Bits	0	.222	.485	.807	1.222	1.807	.807
Number of tenable hypotheses remaining after choice is made.	7	6	5	4	3	2	1

6 TENABLE HYPOTHESES

Responses	Values					
++++	15	3.945	8.775	15	23.775	38.775
+++-	5.86	1.543	3.426	5.860	9.284	15.138
++--	-1	-.263	-.585	-1.000	-1.585	-2.585
+---	-13	-3.419	-7.605	-13.000	-20.605	-33.605
----	-15	-3.945	-8.775	-15.000	-23.775	-38.775
+++	7	1.841	4.095	7.000	11.095	18.095
++-	1.67	.467	.975	1.670	2.642	4.317
+--	-5	-1.315	-2.925	-5.000	-7.925	-12.925
---	-7	-1.841	4.095	-7.000	-11.095	-18.095
++	3	.789	1.755	3.000	4.755	7.755
+-	-1	-.263	-.585	-1.000	-1.585	-2.585
--	-3	-.789	-1.755	-3.000	-4.755	-7.755
+	1	.263	.585	1.000	1.585	2.585
-	-1	-.263	-.585	-1.000	-1.585	-2.585
Information Bits	0	.263	.585	1.000	1.585	2.585
Number of tenable hypotheses remaining after choice is made.	6	5	4	3	2	1

5 TENABLE HYPOTHESES

Responses	Values				
++++	15	4.830	11.055	19.830	34.830
+++-	5.86	1.886	4.314	7.742	13.607
++--	-1	-.322	-.737	-1.322	-2.322
+---	-13	-4.186	-9.581	-17.186	-30.186
----	-15	-4.830	-11.055	-19.830	-34.830
+++	7	2.254	5.159	9.254	16.254
++-	1.67	.537	1.275	2.208	3.870
+--	-5	-.610	-3.685	-6.610	-11.610
---	-7	-2.254	-5.159	-9.254	-16.254
++	3	.966	2.211	3.966	6.966
+-	-1	-.322	-.737	-1.322	-2.322
--	-3	-.966	-2.211	-3.966	-6.966
+	1	.322	.737	1.322	2.322
-	-1	-.322	-.737	-1.322	-2.322
Information Bits	0	.322	.737	1.322	2.322
Number of tenable hypotheses remaining after choice is made.	5	4	3	2	1

4 TENABLE HYPOTHESES

Responses	Values			
++++	15	6.225	15.000	30.000
+++-	5.86	2.431	5.860	11.720
++--	-1	-.415	-1.000	-2.000
+---	-13	-5.395	-13.000	-26.000
----	-15	-6.225	-15.000	-30.000
+++	7	2.905	7.000	14.000
++-	1.67	.692	1.670	3.340
+--	-5	-2.075	-5.000	-10.000
---	-7	-2.095	-7.000	-14.000
++	3	1.245	3.000	6.000
+-	-1	-,415	-1.000	-2.000
--	-3	-1.245	-3.000	-6.000
+	1	.415	1.000	2.000
-	-1	-.415	-1.000	-2.000
Information Bits	0	.415	1.000	2.000
Number of tenable hypotheses remaining after choice is made.	4	3	2	1

3 TENABLE HYPOTHESES

Responses	Values		
++++	15	8.775	23.775
+++-	5.86	3.426	9.284
++--	-1	-.585	-1.585
+---	-13	-7.605	-20.605
----	-15	-8.775	-23.775
+++	7	4.095	11.095
++-	1.67	.975	2.642
+--	-5	-2.925	-7.925
---	-7	-4.095	-11.095
++	3	1.755	4.755
+-	-1	-.585	-1.585
--	-3	-1.755	-4.755
+	1	.585	1.585
-	-1	-.585	-1.585
Information Bits	0	.585	1.585
Number of tenable hypotheses remaining after choice is made.	3	2	1

2 TENABLE HYPOTHESES

Responses	Values	
++++	15	15
+++-	5.86	5.86
++--	-1	-1
+---	-13	-13
----	-15	-15
+++	7	7
++-	1.67	1.67
+--	-5	-5
---	-7	-7
++	3	3
+-	-1	-1
--	-3	-3
+	1	1
-	-1	-1
Information Bits	0	1
Number of tenable hypotheses remaining after choice is made.	2	1

Creativity Tests

Four scores, Fluency, Flexibility, Originality, and Elaboration are derived from the results of the tests.

1. A Fluency score is obtained by counting the number of responses given, excluding only those which are irrelevant or repeated.

2. the Flexibility score is the number of runs revealed in responses in terms of the principles. These principles vary from task to task. In task I these are manipulation, alteration, and dynamism.

a. Manipulation includes changes in accessories, color, orientation, number.

b. Alteration includes changes in dimensions, design, materials, use, and kind.

c. Dynamism is based on any operation which animates the toy giving it either eye appeal, ear appeal, or motion. In task II the three principles are ornamental, household, container, holder, and scientific-mechanical. In task III the principles are life-nature, ornamental-household, and scientific-mechanical.

3. Originality scores are obtained by summing the weighted scores given each response according to the principles used in defining the flexibility score.

4. Elaboration is given a score of one or two. To obtain a score of two, a response must indicate specifically

the purpose of the change, the method to be employed in making the change or the materials with which the change is to be effected.

The following examples (for further examples see Yaramoto,1962) will clarify actual scoring procedures. The The first number stands for fluency; the second, for flexibility; the third, for Originality; and the fourth, for Elaboration.

Example I. (Fluency 7; Flexibility 2; Originality 14; Elaboration 9)

Response 1. Make it walk ______________________ 1D22

2. Lengthen the tail __________________ 1A21

3. Put it on wheels _________________ _1A21

4. Bigger eyes _______________________ 1A21

5. Bigger nose _______________________ 1A21

6. Rubber tip on the nose so it will feel wet ________________________ 1A22

7. Removable spots ____________________ 1A21

Example II. (Fluency 4; Flexibility 4; Originality 8; Elaboration 8)

Response 1. Put wheels on it so it can be pulled _____ 1A22

2. Put a barking device inside the dog so it will bark when squeezed _________ 1D22

3. Build the dog so that the head would move up and down ______________________ 1A22

4. Make the eyes blink when the head is moved ______________________ 1D22

Example III. (Fluency 13; Flexibility 8; Originality 27; Elaboration 18)

Response 1. Straighten out its head ______________ 1M31

2. Make it larger ______________________ 1A21

3. Put a non-tearable skin on it __________ 1A22

4. Give it moveable eyes ______________ 1A21

5. Give it a mechanical bark ____________ 1D22

6. Give it eyes that light up ____________ 1D11

7. Put on a real looking collar __________ 1M11

8. Have a leash ______________________ 1M11

9. Put rollers of wheels on it __________ 1A21

10. Change the black spots to white spots _____ 1M32

11. Give it blue eyes that shine __________ 1M32

12. Curl its tail ______________________ 1A21

13. Make one eye red and the other black ______ 1M32

Example IV. (Fluency 6; Flexibility 1; Originality 6; Elaboration 6)

Response 1. Mascot ______________________ 1011

2. Center piece ______________________ 1011

3. Decoration ______________________ 1011

4. As an object on which to use new ideas ____ 1011

5. In a children's skit ____________________ 1011

6. As a "comic showcase" ____________________ 1011

Example V. (Fluency 5; Flexibility 5; Originality 8; Elaboration 7)

Response 1. As a pillow ____________________ 1011

2. As a pyjama holder ____________________ 1022

3. As a paper weight ____________________ 1011

4. On a bigger scale as a laundry bag ________ 1032

5. For throwing at children ____________________ 1011

Example VI. (Fluency 7; Flexibility 7; Originality 11; Elaboration 13)

Response 1. Book ends ____________________ 1022

2. As a life preserver in water ____________ 1012

3. Messenger ____________________ 1022

4. Shoe Cleaner ____________________ 1012

5. As a purse ____________________ 1022

6. As a relic ____________________ 1011

7. Money box for change in the house __________ 1022

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